DIGEST OF INDUSTRIAL AND TECHNICAL DEVELOPMENTS

Chemical Engineers and Atomic Energy

GUEST of honour at the annual dinner of the British Chemical Plant Manufacturers' Association held at Grosvenor House on October 31 was Sir John Cockcroft, director of AERE, Harwell. He spoke of the severe technological demands of the atomic energy field, and said that atomic plants are becoming more and more chemical engineers' dreams. The emphasis is now moving away from the mechanical engineering aspects to chemical engineering. Uranium extraction he described as being far from its peak. In the U.S.A. the amount of uranium ore processed is soon to be increased from 3 million to 6 million tons a year, and by the time present plans have been fulfilled the free world will be providing 30,000 tons of uranium oxide a year. Some £60 million have been spent on uranium extraction plants in South Africa. Even larger capital expenditure will have to be made in future, especially in countries like Canada which is certainly the El Dorado of the uranium mining industry of the future. Sir John saw all of this representing a great opportunity for the Chemical Plant Manufacturing Industry.

In the field of basic atomic energy materials, the demand for super-pure reactor-grade graphite grows rapidly with time whilst exotic materials such as beryllium, niobium, zirconium, are demanded in tens of tons when a decade ago they existed in tens of grams only. "We are also still interested in finding a really cheap process for production of heavy water—at a cost even lower than the present U.S. cost," added Sir John. We were expecting some reference to heavy water, as we knew that our remarks about the mess that was made over the N.Z. heavy water project (*Digest*, Sept. 1956, p. 238) reached the attention of the A.E.A. board among other interested parties.

Sir John expressed a belief that many of the lessons learnt in building plant for atomic energy, and the processes and technology used have their applications in fields outside atomic energy. He cited the uses of gas bearings in circulating pumps and the use of pulsed columns for extraction processes. This was, he said, an additional reason for B.C.P.M.A. members to take an active part in A.E.A. work. He concluded by drawing the attention of his audience to the facilities of Harwell's new satellite, the Wantage Radiation Laboratory, which will have very powerful radiation sources available for studying industrial applications of irradiation. The attendance at this dinner was just over 600—a record for B.C.P.M.A.

Styrene Production at Grangemouth

A MAJOR extension of the Forth Chemicals factory at Grangemouth, which expands the capacity of the styrene plant to well over 30,000 tons a year, was officially opened on November 7. This output should be sufficient to satisfy all Britain's needs for styrene monomer without the need for any further "dollar" imports. This assessment takes into account not only the established industrial uses of styrene (including the production of synthetic rubber at the plant with a capacity of 50,000 tons of GR-S rubber now being built at Fawley, which will absorb some 15,000 tons of styrene) but also those applications which are likely to be transferred from the laboratory bench to industrial production in the near future.

Key material in the manufacture of styrene is ethylene. As Mr. J. M. Pattinson, one of the Forth Chemicals directors, told the assembled company at the opening ceremony, ethylene forms the base of the ever increasing number of petroleum chemicals which are beginning to be manufactured in this country, and it is for this reason that new chemical plants are being located at Grangemouth, close to the ethylene supply. Simultaneously, the ethylene output itself has to be increased.

A Fully Integrated Factory

ABOUT 7 tons of petroleum feedstock are required to produce a ton of ethylene. Grangemouth is clearly becoming a fully integrated succession of plants, the output of which ranges from the relatively simple oil-products made in the oil refinery to the wide variety of petroleum chemicals which are either required by the chemical industry as feedstocks or in some cases may be finished products for the market. The integrated development of this factory has led to economies in overheads. For example, large quantities of steam power and cooling water are needed in the manufacture of styrene, all of which are available economically by integration of these costly services with British Hydrocarbon Chemicals and the BP Refinery next door. Mr. Pattinson said there was no doubt that the large-scale manufacture in this country of petroleum chemicals has come to stay. "There can be no reason for the country continuing to import these when the raw material, refined petroleum, is now available in such large quantities from the refineries which have been built here since the war. The consumption of oil products also we estimate to rise very substantially in the next few years, necessitating yet further increases in refining capacity," was Mr. Pattinson's concluding comment.

A Guide to Scientific Education

THE conclusion reached by the Zuckerman Committee (the Committee on Scientific Manpower of the Advisory Council on Scientific Policy) in its recently published assessment of the long-term demand for scientists and engineers boils down to a recommendation that the number of people who graduate in science and applied science should be doubled over the next ten to fifteen years. In the committee's calculations, this increase in graduate output should make good the expected 60% increase in the number of scientists and engineers required by industry by 1966 over the number (135,000) at present. The committee clearly point out that their report is a guide to action for education authorities, and is not a prophecy about the scientific content of British industry in ten years' time. But the question arises as to how sound a guide

it is. The authors themselves claim for the report only the merit that it started with a better picture of the employment of scientists and engineers than previously had been available. It will have another merit, however, if it should indirectly spotlight the piecemeal nature of the attack on the urgent problem of providing an adequate number of liberally-educated scientists and engineers.

Co-ordinated Action Necessary

Perhaps the committee limited the scope of their work too narrowly—to merely suggesting targets for the output of universities, without keeping a sufficiently watchful eye on the possibilities of attaining those targets. Admittedly, the committee is of the opinion that there will be a sufficient number of talented boys and girls to be trained at the rate it recommends, although it is conceded that to increase the stock of scientists to 220,000 by 1966 would present a "remarkable achievement". The vital matter of the adequacy of secondary education facilities, however, the committee "assumed". Obviously machinery is required to produce an integrated plan for training more scientists and engineers. Re-thinking on university training is called for so that, in the words of George Barnes (principal of the University College of North Staffordshire) to a recent conference of educationalists at Kendal, the scientist is "humanised" and the arts man is enabled to appreciate what science is about and to talk to the expert. In this context it is worth recalling the appeal made by Dr. Percy Dunsheath, chairman of Convocation of London University, in a recent speech to the University's School of Pharmacy, for more "peak and plateau education—where the peak, though narrow, is an Everest, and the plateau, although moderate in elevation, has a wide area".

Recruits for the Chemical Industry

SHORTAGE of trained manpower is far from being solely a British problem. According to a recent estimate made by the U.S. Manufacturing Chemists Association, the American chemical industry alone will be short of 93,000 scientists and engineers by 1965. To encourage young people to choose science as a career, the Association has launched a nation-wide educational programme. Among other things it is offering to schools supplementary aids to general science teaching, including film strips and teaching charts. A 16-page careers booklet is also being prepared, comparable, we gather, to the one produced by the Association of British Chemical Manufacturers with the title *The Chemical Industry Calling You!*

In this context it is worth noting that the Midlands branch of the Institution of Chemical Engineers is organising a symposium dealing with various aspects of chemical engineering education for April 9-11, 1957. Topics which will be discussed will include the requirements of industry, methods of training, new trends in teaching, and recruitment to the chemical engineering profession. We shall be publishing fuller details in due course, but readers who are interested in this important symposium can obtain further particulars from the hon. secretary of the Midlands branch—W. H. Husband, Chemical Engineering Dept., University of Birmingham, Edgbaston, 15.

A New Design of Grinding Mill

BCURA have carried out fundamental work on the problem of the relative balance of physical and chemical rate-determining processes, with attention focused on processes involving the transfer of mass, heat, and momentum on both laboratory and plant scale. In the laboratory the component parts of an individual process may be isolated and studied separately. The results of these individual studies then have to be assembled in the correct relation to one another to represent full-scale plant behaviour. This procedure, needless to say, is full of mathematical difficulties. A simple mathematical device described in a recent paper (Brown, R. L., *Journal of the Institute of Fuel*, 1956, **29**, 184, 218-231) makes it possible to calculate the performance of a mill operating in continuous closed circuit grinding from small-scale batch data giving the breakage in the mill and the sharpness of cut in the classifier. The method has the advantage of requiring no more than a simple sieve analysis. This work suggested a new type of mill design. A model has been constructed, and this consists of a cone rotating about its vertical axis and with its apex uppermost. Around the periphery of the cone near its base a cage containing a number of balls is fitted, and the material is broken up through its passage through the balls. The operation is such that the increase in speed gives a greater reduction of particle size. An outstanding mechanical advantage is the simplicity of the machine.

Industrial Television

IN our recent article on nitroglycerine manufacture (*British Chemical Engineering*, September, 1956, p. 254) we mentioned the proposal to use television for controlling the position of the nitroglycerine spent-acid interface in the separator vessel of the Biazzi plant. Other uses have been suggested in a recent paper (*J.I.H.V.E.* Volume 24, p. 287). These include inspection of liquid level in gauge glasses where the gauge is fitted in a position unfavourable for successful visual observation. It might be argued that there are available remote level indicators for such situations. However, 100% reliability for such instruments cannot generally be claimed. Television has an application here, and it has other advantages in as much as an actual view of a level gauge can be transmitted to a number of places simultaneously. Inaccuracy in presentation of the liquid level is also impossible with television systems. Another use is the viewing of furnace flames—of importance in the accurate adjusting of burners, especially in pulverised fuel furnaces. Often a good idea of the conditions in a furnace can be obtained by observing the combustion by looking through a suitable opening in the furnace structure, using a darkened glass for the purpose. However, it is difficult for one person to make adjustments of the fuel feeding and burning equipment when such a method is used. Remote visual inspection by means of a television camera has the advantage that a picture may be given on the control panel and close to the point where adjustments to burners have to be made. The furnace operator is then in a position to judge accurately the combustion conditions and to control them. A form of flame failure indication is also provided.

The New DSIR Research Council

ON November 7 the Department of Scientific and Industrial Research Act, 1956, came into force. Under that act a Research Council is established to decide upon broad issues of policy. The initial membership of this body has just been announced. We are impressed by the quality of its individual members, who should be able, collectively, to give the DSIR the kind of direction which will render that organisation even more effective than it has been.

The chairman of the new council is Sir Harry Jephcott (chairman, Glaxo Laboratories, Ltd.). The other members are: Sir Eric Ashby (President and Vice-Chancellor, Queen's University, Belfast); Professor C. E. H. Bawn,

F.R.S. (Grant-Brunner Professor of Inorganic and Physical Chemistry, Liverpool University); Sir Hugh Beaver (managing director, Arthur Guinness, Son and Co., Ltd.); Professor P. M. S. Blackett, F.R.S. (Professor of Physics, Imperial College of Science and Technology, London University); Mr. H. Douglass (general secretary, Iron and Steel Trades Confederation); Sir Walter Drummond (director of George Angus and Co., Ltd.); Mr. W. L. Heywood (general secretary, National Union of Dyers, Bleachers and Textile Workers); Dr. Willis Jackson, F.R.S. (Director of Research and Education, Metropolitan-Vickers Electrical Co., Ltd.); Sir Philip Johnson (deputy chairman, R. and W. Hawthorn, Leslie and Co., Ltd.) Professor E. A. G. Robinson (Professor of Economics, Cambridge University). Dr. H. W. Melville, F.R.S., the secretary of the old advisory council, will be secretary of the new council.

The 1956 Nobel Chemistry Prize

THE Nobel Prize for chemistry for 1956 is shared by two scientists working in the field of the mechanisms of chemical reactions—Sir Cyril Hinshelwood (who is president of the Royal Society and Dr. Lee's Professor of Chemistry in Oxford University) and Prof. Nikolai Semenov, director of the Institute of Chemical Physics of the Soviet Academy of Sciences. Hinshelwood's work is associated particularly with the breaking down of chemical reactions into a succession of simple steps, which demonstrated that the kinetics of many reactions, not otherwise comprehensible, make sense. Much of his work has been important not only to chemistry theory but to the chemical industry.

Prof. Semenov has been director of the Institute of Chemical Physics in Leningrad since its inception in 1931, when he was 35 years old. He won a Stalin Prize in 1941. He is the first Russian chemist and first *Soviet* citizen ever to receive a Nobel award. (This rather surprising fact is explained by the continued refusal of the Soviet Government to allow its nationals to accept Nobel Prizes, a policy parallelled by that of Hitler.) Although Prof. Semenov was trained as a physicist, most of his life's studies have been on the mechanisms of chemical reactions. In 1934 he published a classic book, which appeared as an English translation entitled *Chemical Kinetics and Chain Reactions* a year later. In this work he described experiments just completed at the Leningrad laboratory which showed that a relatively small number of active particles (oxygen atoms, for instance) admitted into a chemically unstable system is able, "leaven-like, to call forth the reaction at temperatures which are much below the reaction temperature corresponding to normal conditions". The active particles enter the reaction to form branching chains, thereby overcoming the chemical "resistance" of the system. His school played a large part in working out the details of the theory of branching-chain reactions, and his investigations coupled with those made at Oxford and elsewhere laid the foundation of the theory of non-branching chain reactions. His later books have dealt with combustion and explosions, and chemical kinetics in relation to chemical activity. He was made a professor of Moscow University in 1944.

Flexible Hoses

DEVELOPMENTS that have taken place recently in the advisory service of Compoflex include the removal of its London Flexibles Centre to larger premises, and the launching of a quarterly journal entitled *Arteries of Industry*. The first issue, which contains 16 pages and is printed on art paper in two colours, is strikingly but not over-elaborately produced. The contents include a signed article on flexible hoses in an I.C.I. factory that certainly reflects the intention of the publishers to allow contributors to express their own opinions freely. The aim of the company is to publish articles of technical and general interest and to send the journal to users and potential users of flexible tubes and hoses. The new premises of the London centre, which also house the London offices and showrooms of the company at 23-25, Northumberland Avenue, W.C.2, were recently opened by Sir Norman Kipping (director general of the Federation of British Industries).

Chemical Production and Exports

PRODUCTION in the chemicals and allied industries in the first six months of 1956 was 2% above that of 1955. Although this represents a marked falling off on the previous rapid rate of expansion, in general, the output of chemicals has been fully maintained. Details of the progress of new chemical exports during 1955 and 1956 were published recently in a review in the *Board of Trade Journal*. During 1955, the value of the chemicals group of exports exceeded that of the other two groups of new exports considered (engineering products and "other" exports), but in the first half of the current year was much the same as that for 1953.

The increase in new chemicals during 1955 was mainly due to the growth of trade in synthetic detergents and in the petrol additive, tetra-ethyl lead. Five-and-a-half million gallons of the additive were sent to 40 different countries, five times the quantity exported in 1953. Exports of synthetic detergents were two-and-a-half times greater than in 1953 and are valued at some £6.7 million. Although figures for the current year show a continued expansion in the exports of these products, increased competition can be expected in the future as detergent plants are being erected abroad, notably in Belgium and Italy the present largest markets.

Most of the remaining exports in the chemical group were pharmaceutical products. Exports of antibiotics reached nearly £8 million; although the value of those exports was lower than in previous years. The output of plastics materials for the first half of 1956, 168,000 tons, was nearly 4% above that for the first half of 1955. This represented a considerable easing on the previous rate of increase, which for 1955 was 16% above that of the previous year. The output of thermoplastic plastics was up by 5%, and that for thermosetting plastics up by 3%. Net sales of phenolic and cresylic materials were 6% lower than those in the first half of 1955.

EDTA and Boiler Scale

ONE of the problems of evaporator and boiler operation is the formation of scale upon the evaporating or heating surface. An interesting chemical method for treatment of the surfaces of evaporators used in the sugar industry has been reported in a recent number of the *International Sugar Journal*. This seems to offer advantages of wider application than earlier chemical methods. The substances used are chelating agents, the most useful member of the group being EDTA. The process of treatment consists of circulating the EDTA solution over the fouled surfaces, with the result that the metallic constituents of the scale to go into solution as chelates, while any silica present separates out as a sludge. One of the drawbacks of the method is the high cost of EDTA which makes it necessary to have on hand plant for its regeneration. However, this may be offset by the advantages accruing from the avoidance of the usual weekend shut

down enforced by scale formation at the heating surfaces of most sugar evaporators. Four hours is said to be sufficient to get a completely clean evaporator surface with EDTA treatment.

I.C.I.'s New Olefin Plant

THE second olefin plant erected at Wilton by the Billingham Division of I.C.I. has started up. Plans for this £6 million plant were announced in March 1954, three years after the No. 1 Olefin plant came on stream. Like its predecessor the No. 2 Olefin Plant is broadly divided into three sections: the pyrolysis section which converts light hydrocarbon oils into a mixture of gases and crude motor spirit; the gas separation section; and a small section which refines the crude motor spirit which is piped to the Billingham factory for blending.

The separated gases are the raw materials for other chemical plants which, in turn, provide the raw materials for the manufacture of polythene, "Terylene", "Perspex", glycol anti-freeze and a variety of new organic chemicals. The processes operate over an extremely wide range of temperatures. In the "cracking" process the steam used is heated to 1700°F. while in the system to liquefy and fractionate the gases the temperature is as low as minus 200°F. One of the operating difficulties associated with the latter section stems from the need to remove all water vapour from the gases: the presence of even small quantities of moisture would cause the low-temperature sections of the plant to ice up. Therefore it was necessary to subject the low-temperature system to continuous drying for several weeks before start-up in order to remove all but minute traces of moisture.

The second olefin plant provides permanent employment for about 180. When the third olefin plant commences operations in 1959, the number employed on olefin works at Wilton will have increased from 350 in 1955 to over 700. When all three plants are producing, the total ethylene output will exceed 100,000 tons a year together with an approximately equal amount of other olefins—propylene, butylenes, and butadiene.

No. 2 Olefin Plant was designed by Kellogg in close collaboration with I.C.I. staff and was constructed by Kellogg International Corporation to I.C.I.'s order. The design, engineering and construction of No. 3 Olefin Plant is also being done by Kellogg. This firm was the first to propose the special system of cracking of light oils used at Wilton, and their design of the gas separation process has proved very successful in producing consistently ethylene of the unusually high quality specified by I.C.I. for polythene manufacture.

Britain's Expanding Refinery Capacity

THE Esso Petroleum Co. Ltd. are seeking permission for the industrial development of approximately 1000 acres of land in the Milford Haven area. Sir Leonard Sinclair, chairman and managing director of the company, in a recent announcement, explained that Esso have under consideration the construction on the site of a new large oil refinery. The Company's plans at this stage are tentative only. Planning approval has to be obtained and a number of important problems have yet to be solved. The developments, Sir Leonard continued, are the outcome of long-term planning of the company's future expansion to meet rapidly increasing oil consumption in the United Kingdom. The initial purchases of land were made more than eighteen months ago, and further purchases have been made subsequently. There is no connection, he said, between the present proposals and recent international events, nor with any other proposed developments in the Milford Haven area. A further development announced by Sir Leonard was that his company's Fawley refinery, the largest in the British Commonwealth, is being expanded to increase its throughput of oil to 10½ million tons a year by the end of 1958.

A new £6½ million crude distillation unit is planned to come on stream at Shell Haven Refinery, Essex, by the end of 1958. With a design capacity of 11,000 tons (80,000 barrels) per day, this will raise the refinery's capacity to 7¾ million tons a year, almost double the present figure. The plant incorporates several novel features. The furnace which heats the oil will be one of the largest in use in the oil industry, with a heat absorption of over 200 million Btu per hour. From the furnace, the crude enters the main tower, and from there fuel oil is produced directly as a bottom product. The special naphtha cut from which the platformer makes components for highest-grade motor gasolines will also be produced, as a single stream, by the new distiller. The unit has been designed to Shell standards by E. B. Badger and Sons Ltd., who will also erect it.

The Bread Subsidy and the Fortification of Flour

IN a forthright book "Breads White and Brown" (Pitman Medical Publishers Co. Ltd., London, 30s.) just published, R. A. McCance and E. M. Widdowson untangle the web of interests, prejudices, tastes, knowledge and ignorance which through the ages and in times of abundance and of scarcity have influenced the composition of flour consumed in Britain and other countries. They have reviewed the history of bread for the past 3000 years, and the exhaustiveness of the work is reflected by the appended list of over 700 references. The book's publication is timely, for it coincides with the cessation of the subsidy on bread of 80% extraction and, therefore, with the freeing of millers to compete with each other in an open market in the production of flours of various extractions to suit different palates and purses.

The Flour (Composition) Regulations, 1956, which came into force at the same time continue the requirements for low extraction flours to be fortified where necessary, with vitamin B_1, nicotinic acid, and iron in quantities that produce a flour about equivalent to an 80% extraction flour. The regulations have the effect of ensuring, therefore, that the standard of the new fortified flours will be that approved on the basis of available evidence by the independent panel of experts under the chairmanship of Lord Cohen, which reported earlier this year. Obviously the chemical industry will be required to increase its supply of the flour additions to millers. By what amount will depend on the popularity of the lower extraction flours, but it has been estimated that the extra quantity per week may be as much as 2½ cwt. of vitamin B_1, 15 cwt. of nicotinic acid, and 2½ cwt. of iron.

GUIDE TO PUMP SELECTION

IT is proposed to publish the two-part article on the selection of pumps for the chemical and process industries, in reprint form. Copies of this reprint (to be published at 1s. 6d. per copy, post free) may be obtained from: The Circulation Manager, Drury House, Russell Street, London, W.C.2. Remittance must accompany the order.

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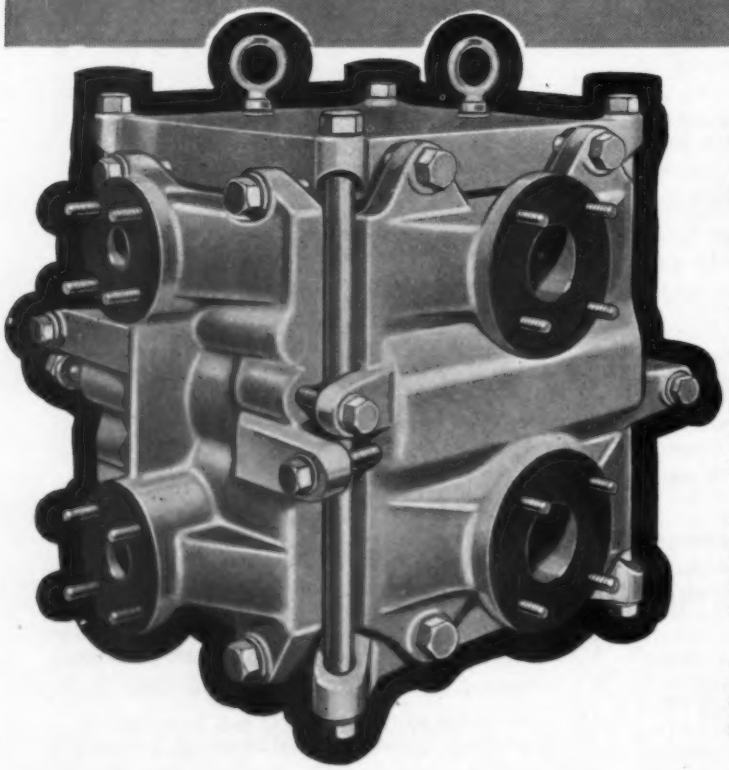
Heat exchanger standardisation



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BRITISH CHEMICAL ENGINEERING
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Rainbow through the Smoke

PROVERBIALLY the air is free, and perhaps because it costs nothing it has been scandalously polluted. We have gone on allowing factories to foul the atmosphere long after the technical means for preventing this kind of pollution were forthcoming. On paper, the legislation covering atmospheric pollution may have looked adequate. It was, however, piecemeal legislation and, consequently, the nexus of laws dealing with smoke operated like a net which let practically all the fish through. Only the most blatant pollutants have been adequately controlled.

The Clean Air Act, 1956, which replaces no less than twelve separate enactments, should open up a new era. It should put a stop to most atmospheric pollution, though one considerable source of pollution—the exhaust gases from petrol and diesel engines—still remains untouched.

Progressive industrialists and technologists who have long maintained that all factories should consume their own smoke should see that target realised within a few years. No insuperable technical difficulty stands in the way. It has been argued (with a callousness that is shameful in view of the medical evidence about the effects of pollution) that the new Act will not change anything, because, like the air-pollution provisions in the Public Health Acts, it cannot be seriously implemented. In our opinion, nothing could be farther from the truth. Industry must take this new law very seriously. It is true that many local authorities have neglected in the past to use the somewhat limited powers which Parliament had given them. The Clean Air Act, however, is permissive only in respect of the institution of "smoke control areas" (and this affects only the domestic consumer): *its industrial clauses are not permissive.*

The Act was drawn up with all due regard to practical conditions applying in industry. This reflects the fact that the Beaver Committee, upon whose report this Act is based, contained sound technical men from industry. It cannot be stressed too strongly that the aim of the Act can certainly be realised in practice. Indeed, any industrial firm which does not conform with the law will brand itself as technically incompetent. To fly a plume of dark smoke from a chimney stack will be an admission of technical inefficiency, a badge of incompetence for all to see.

It is abundantly clear that there is no intention to apply this Act by summonsing each and every unwitting offender and subjecting him to the utmost rigours of the law. The intention is to assist industry to meet its legal obligations, to enable it to comply voluntarily with an excellent law. We may expect that the local authorities which enforce the law will exercise as much patience as each case deserves, and that they will provide firms with technical advice and assistance on their pollution problems in much the same way as happens in connection with offences against the Alkali Act.

The spirit in which the law is implemented will be all-important. It should match the spirit with which the Alkali Inspectorate tackles its problems. The "smoke inspectors" will be appointed by local authorities, not by the central government. A small nucleus of "smoke inspectors" already exists and does its best to take action against infractions of the dozen different acts which the Clean Air Act renders obsolete. Not every smoking factory will come within the province of this inspectorate. Special atmospheric pollution problems (those which are "primarily technical" problems) will remain the concern of the Alkali Inspectorate.

Most important will be the quality of the "smoke inspectorate". By far their easiest job will be to decide whether the smoke from a particular factory is inoffensive. These inspectors will also be responsible for seeing that industrialists have taken every possible step towards the reduction of grit and dust emitted from their plants. The powers conferred by the Act are wide; for example, before a firm will be allowed to erect a new chimney stack it will have to satisfy the local authority that the stack is high enough to prevent the smoke, grit and gases emitted despoiling the neighbouring ground. A local authority will be entitled to reject a plan if the chimney is evidently incapable of doing its job properly. This means that inspectors will need to be able to do much more than make a Ringelmann test. They will have to understand combustion theory, and they will need to be well informed on such detailed matters as the performance of chimney stacks. It is reckoned that a three-months' course will be adequate for training a "smoke inspector".

As a result of the passage of this law, industrialists will be stimulated to ensure that their equipment is as efficient as possible. This will encourage good plant design, good operation and good maintenance. Higher management will need to show that they are interested in the work of their furnace and boiler operators. Instrumentation of fuel-burning equipment will have to be adequate, and in this connection it is worth noting that a committee of the British Standards Institution is now engaged in drawing up specifications for smoke indicators and recorders. All these measures should bring about a considerable saving of fuel, and that saving will go a long way towards meeting the cost of any additional instrumentation that may be necessary. Some people have suggested that there should be financial incentives to firms to encourage the installation of the plant required to enable industrialists to comply with the Act. There seems to be little justification for this idea. First, it would introduce a new concept if people were to be subsidised for obeying the law of the land. Secondly, no new financial arrangement is really necessary. The amount of fuel saved through avoiding bad combustion will generally enable the new installation to come under the provisions already made by the Government for loans for fuel-saving plant, so that industrialists can borrow any capital they may require to raise from the Government on highly advantageous terms. This financial help does not at present apply to plant for arresting grit and dust, but it is to be hoped that this equipment will be brought under the same provisions in the next budget.

Air-cooled Heat Exchangers

Because of the rising cost of water and other factors, there is an increasing trend to use air industrially as a cooling medium

D. KAYE, B.Sc. (Eng.), Chem. Eng.

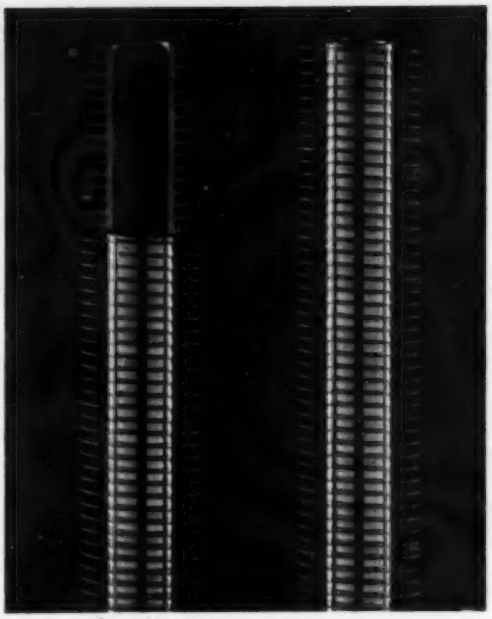


Fig. 1. *Integron high-fin tubing.*

OF the two main industrial cooling media, water and air, water has long taken pride of place, but in recent years the use of air as a cooling medium has been more extensively applied. Air is the ultimate cooling medium, and all water used for industrial cooling is eventually cooled by it either in a cooling tower or down the drain to the rivers or the seas. It seems reasonable, therefore, to consider direct cooling with air, thereby cutting out the intermediate water-cooling stage which involves heat exchangers, cooling towers, pipe-work, valves and pumps for the cooling-water circuit. Moreover, industrial cooling water is sometimes scarce, and its cost is rising.

In some places the demand for cooling water has increased so tremendously in, say, the last 50 years that its cost has risen to as much as 2s. 6d. per 1000 gallons. In areas like the Middle East, where cooling water is very scarce or non-existent, the use of air as a cooling medium is a necessity. Even where water is available in substantial quantities, air cooling may still have its advantages, as the water may be unsuitable and its use, therefore, would lead to costly corrosion or scaling difficulties or to expensive water treatment.

Heat-transfer Considerations

Where there is a difference in inside and outside heat-transfer co-efficients, the use of some form of extended surface is indicated. In Table 1 are tabulated cost comparisons for plain 1-in. tubes and finned 1-in. tubes for different heat-transfer conditions. It can be seen that, where co-efficients are nearly equal, there is no positive case for employing fins; but as the difference in co-efficients increases the advantage of finning becomes more and more apparent and, in the case where the ratio of coefficients is 100 : 1, the cost of surface per Btu/°F heat transferred can be reduced to about one-quarter by the use of fins.

For this comparative study the air-side heat-transfer coefficient has been maintained at 10 Btu/hr/ft²/°F. This is a reasonable figure for the type of finned tubes considered, as it can be attained with relatively low fan horsepowers. It is usual when air cooling is considered to find the fluid or condensing coefficient far higher than the air-side co-efficient, thus a study of heat-transfer conditions in practice leads to the conclusion that extended surfaces should be used.

Many types of extended surface are available, and they include various finned tubes, radiator and matrix constructions, and stud- or peg-type tubes. Among the several kinds of spiral fin on the market are smooth spiral fins, crimped fins, integral fins, wire-wound fins and serrated fins.

Spiral Fins

Smooth spiral-finned tubes, an example of which is shown in Fig. 1, are manufactured in a lathe-like machine. Flat strip is wound on edge into a groove previously formed in the tube wall, and the tube is held steady by a three-point support adjacent to the gilling head. This head comprises a wheel or blunt-nosed tool for groove forming by pressure (not cutting), and two pairs of split wheels for guiding on and stretching the strip and also for completing the key bond. As this process involves stretching, close control is necessary and fairly thick strip must be used. A slight variation of this type of tube is one in which the bond is effected mechanically with small "flaps" at the base of the fins pressed on to the tube surface. No grooving is necessary, but the tube is knurled before fitting the fins.

In the crimped-fin tube the base of the fin is corrugated and the strip is wound on to the tube by a machine similar to that already mentioned. Some manufacturers choose to solder or weld the crimped fins to the tubes. The use of crimped fins allows for thinner and wider strip material to be used. The advantage of spiral fins is that they are easy to make and, with the smooth fins, easy to keep clean. If the fins are crimped cleaning may prove difficult. Disadvantages of smooth fins are that the tube is thinned locally where grooving is adopted, fin width is limited due to stretching, and the degree of thermal contact may vary except under very close production control. All spirally-wound finned tubes may be metallically bonded. Metallic bonds encourage good heat-transfer conditions, and are easy to make and economic on materials; however,

the melting point of the solder limits their application and the possibility arises of the bond breaking down in time due to vibration.

A serrated type of spirally-wound finned tube is also made. Here, instead of being stretched or crimped, the strip is serrated and made into segments extending radially from the tube. The base of the segments consists of a part of the strip turned through 90 degrees and soldered to the tube. The serrating and bending of the fin stock and the winding of the fin stock on to the tube are carried out simultaneously on a machine.

A further type of spiral-fin tube is the Integron tube. This tube is one of the best on the market as far as quality and heat-transfer performance are concerned. Integron fins are part of the tube itself and are made by rotary cold forming from the body of the original plain tube. The tubing is made of non-ferrous material and, as the extended surface is formed from the tube itself, heavy-gauge tubing must be used. The tubes are robust, and have no bonding difficulties. The fins are tapered and smooth for ease of cleaning. However, the surface area obtainable is limited by the method of construction of the tubing and there is a high material-to-surface-area ratio.

Coiled Wire and Punched Fins

In the wire-wound tube a coil of wire, instead of a strip of metal, is fixed to the tube (see Fig. 2). The wire is wound round a former which governs the depth of the wire fin, and the wire coil is fixed into position on the tube with a binding wire and solder wire. The tube is dipped in flux, and is then steam-heated to melt the solder and so create a strong metallic bond. Wire-finned tubes have been made with both internal and external fins. They provide favourable heat-transfer conditions and are economic in the use of materials. However, they are not easy to clean and, as with other soldered fin tubes, the melting point of the solder limits their use.

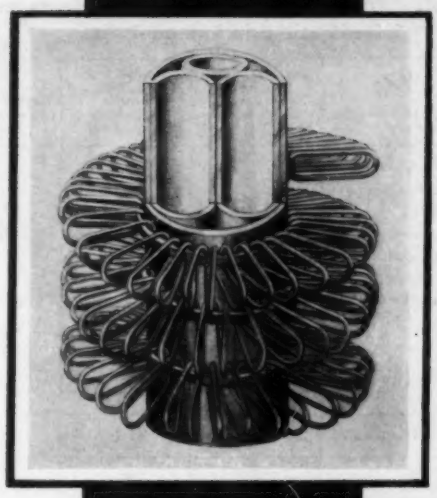
Tubes may also be equipped with fins individually punched to the desired shape, and then push-fitted into position. These finned tubes are easy to manufacture, but may be subject to indifferent fin-to-tube contact, with consequent poor heat transfer. When punched fins are applied to oval tubes, the fins are stamped with oval holes slightly smaller than the shape of the tubing. The fins are provided with small serrations around the holes, and the serrations inside the fins are turned through 90 degrees to obtain good thermal contact. For fin spacing, small distance lugs are punched out of the fins at suitable positions. Automatic machinery to produce this type of tubing is in existence, but the tubing has been manufactured economically by hand. The fins are invariably bonded to the tubes by soldering, etc., or, when steel is employed, by a special hot-dip galvanising process. The great advantage of oval-shaped tubes in coolers is that the pressure drop over the tubes is reduced so that fan horse-powers can be reduced substantially due to the more streamline air flow round the oval shape.

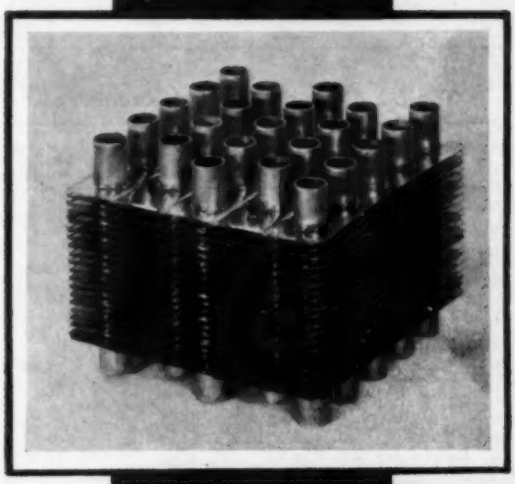
For circular tubes individual fins are sometimes secured by expanding the tube after the fins have been placed into position. This is achieved by passing through the tube a "bullet" which expands the tube and causes the fins to bite into it, thus making good thermal contact (Fig. 4).

In the peg or stud type of extended surface, as seen in Fig. 5, pieces of metal of various shapes are welded on to tubes. This type of extended surface is very efficient from the thermal point of view and is used for economisers and preheaters by boiler constructors.

Radiator Construction

The punched type of extended surface need not be limited to single tubes, and continuous fins extending over





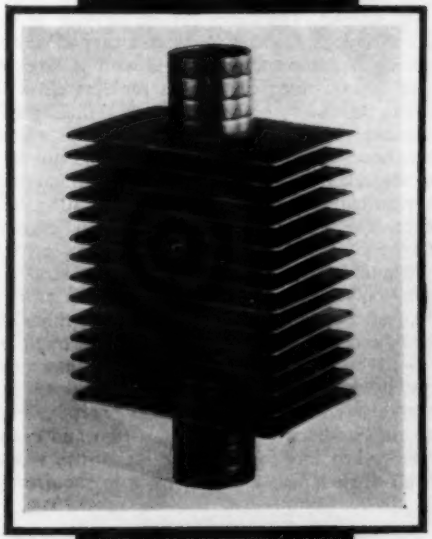


Table 1. Effect of Heat-transfer Coefficients on Cost of Plain and Finned Tubes

Nature of heat-transfer surface	Internal fluid film heat-transfer coefficient, Btu/sq. ft/hr/°F	External fluid film heat-transfer coefficient, Btu/sq. ft/hr/°F	Cost of surface. Cost units per Btu/°F
(A) 1 in. o.d.×18-gauge plain copper tubing ...	20	10	17.2
(B) 1 in. o.d.×18-gauge copper tubing finned with 7 gills per in., ½ in. high	20	10	18.4
(A) As "A" above	50	10	15.4
(B) As "B" above	50	10	8.85
(A) As "A" above	200	10	13.4
(B) As "B" above	200	10	4.08
(A) As "A" above	1000	10	12.95
(B) As "B" above	1000	10	2.82

Table 2. Costs of Materials Compared

Type of Tubing	Cost of tubing. Cost units/sq. ft of external surface
Mild-steel tubing, 1 in. o.d.×18 gauge ...	34.4
Mild-steel tubing, ⅛ in. o.d.×18 gauge ...	42.7
Mild-steel tubing, 1 in. o.d.×18 gauge, with seven copper gills per in., ½ in. high	16.9
Mild-steel tubing, 1 in. o.d.×18 gauge, with eight aluminium gills per in., ½ in. high	7.60
Copper tubing, 1 in. o.d.×18 gauge ...	128.0
Copper tubing, ⅛ in. o.d.×18 gauge ...	113.0
Copper tubing, 1 in. o.d.×18 gauge, with seven copper gills per in., ½ in. high ...	25.0
Copper tubing, 1 in. o.d.×18 gauge, with eight aluminium gills per in. ½ in. high	14.9

a bank of tubes producing the radiator construction (Fig. 3) are well known. The tubes can be circular or elliptical and the continuous fins can be placed very close together, thus making a compact, rigid unit with a large surface area. The disadvantage of placing the fins close to each other is the possibility of clogging and difficulty of cleaning; moreover, individual tubes cannot be replaced if damaged. Bonding of fins is usually carried out by a dipping or soldering process and, therefore, bond failure in time is possible if there is excessive vibration.

Another type of radiator construction employs the matrix type of extended surface. No tubes, as such, are employed and surface areas of passes are increased enormously by corrugated strip metal. The radiator is usually made up of straight-walled passages for fluids to pass adjacent to each other, and the surface area of fluid passes is increased by corrugations. The unit is assembled and mechanically held together before it is dipped to create the metallic bond between walls and corrugations. This type of unit has been made in aluminium and copper and was developed mainly for the aircraft industry where lightweight, air-cooled heat exchangers were required.

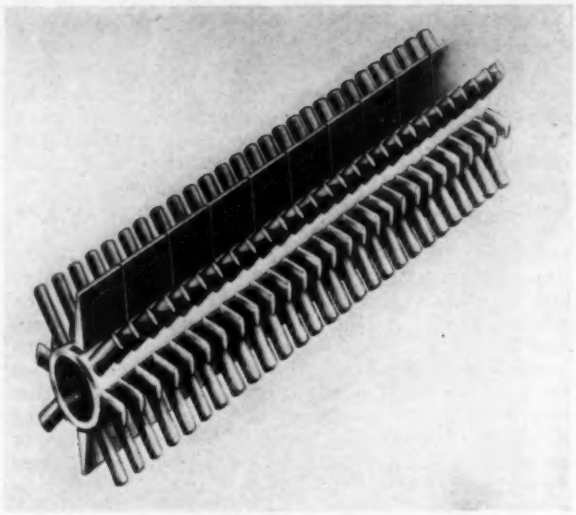


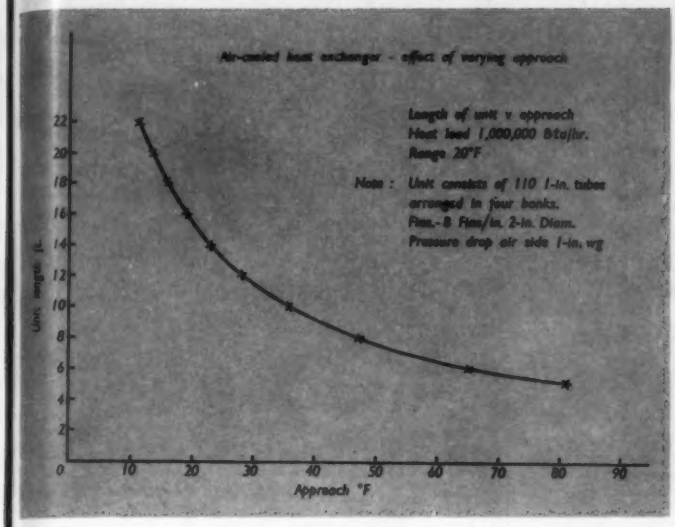
Fig. 5 Extended stud-tube element used for economics and preheaters. (Photo: Babcock & Wilcox.)

Theory of Design

As with any heat exchanger design, the greater the log mean temperature difference (L.M.T.D.), the smaller the surface area required, and this is of particular importance with air coolers, where overall heat-transfer coefficients must be low for power considerations. Fig. 6 illustrates the effect of approach. Here, for a heat dissipation of 1×10^6 Btu/hr with a temperature range of 20°F, the length of a standard unit has been plotted against approach. This is for a unit consisting of 110 1-in. diameter finned tubes arranged in four banks with an air-side pressure drop of 1-in. w.g. It can be seen that, with an approach of 65°F, a unit 6 ft long is required, but for the same heat dissipation a unit of some 18 ft in length is required when the approach is reduced to 15°F. Fig. 7 also indicates the effect of approach. Here it can be seen that the same unit will dissipate 1.8×10^6 Btu/hr with 70°F approach and only 350,000 Btu/hr with a 10°F approach. It follows, therefore, that it is desirable when considering air coolers to design to cold temperatures as high as possible. This can often be done with no disadvantage and sometimes with positive advantage.

The Essential Problem

The problem of designing air-cooled heat exchangers is largely a question of obtaining a high rate of heat transfer with a corresponding low power consumption for the movement of the cooling air, bearing in mind the cost of an equivalent water-cooled system. Actual design procedure given in standard text-books is long and tedious, and specialising firms have brought calculation down to a minimum by using charts, curves, etc. Basically, one calculates internal and external coefficients using standard formulæ. The air-side coefficient must be corrected for fin efficency and the overall coefficient is then obtained. The L.M.T.D. is calculated and corrected for flow arrangement, and, with the heat load, the area required is obtained. The fin efficiency is usually taken from charts derived for the extended surface under consideration. For heat to flow in the extended surface there must be a temperature drop between the fin and the tube and within the fin itself; thus the effective temperature difference between the air and the finned tube will vary and the extended surface


Air-cooled heat exchanger - effect of varying approach
Length of unit v approach
Heat load 1,000,000 Btu/hr.
Range 20°F
Note : Unit consists of 110 1-in. tubes arranged in four banks.
Fins.-8 Fins/in. 2-in. Diam.
Pressure drop air side 1-in. wg
Unit length ft.
Approach °F

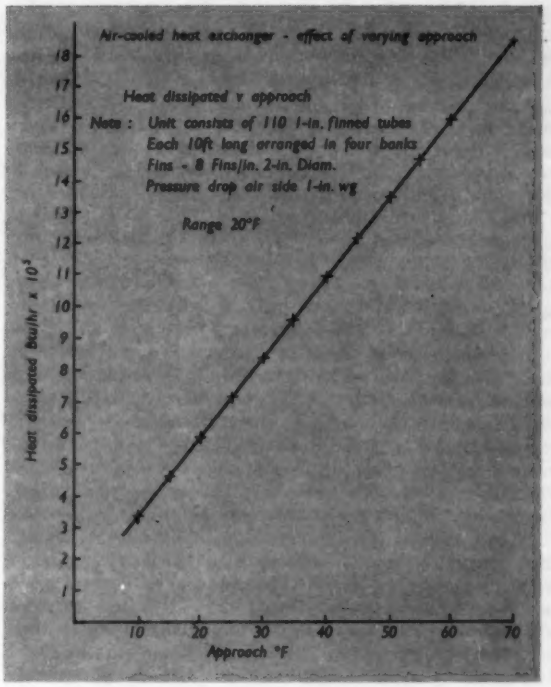

Air-cooled heat exchanger - effect of varying approach
Heat dissipated v approach
Note : Unit consists of 110 1-in. finned tubes
Each 10ft long arranged in four banks
Fins - 8 Fins/in. 2-in. Diam.
Pressure drop air side 1-in. wg
Range 20°F
Heat dissipated Btu/hr x 10³
Approach °F

Fig. 6 (above) and 7, are graphs illustrating the effect of varying the approach on air-cooled heat exchangers.

will not be as effective as the tube. The fin-efficiency correction factor is brought in for this reason. The mathematics for the derivation of fin efficiency will be found in a paper by K. A. Gardner (*Trans. ASME*, 1945, **67**, 621-31).

Factors to be Considered

The main factors which affect fin efficiency are:

(1) *The thermal resistance of the material.* As the thermal resistance of copper is less than stainless steel, copper will tend to have a better fin efficiency than stainless steel.

(2) *Thickness of the fin.* The thicker the fin, the greater the area of cross-section for heat flow and the better the L.M.T.D. and fin efficiency. Ideally, fins should be tapered and the thickness should increase as the fin approaches the tube.

(3) *Fin height.* The higher the fin, the longer the path for heat flow and, therefore, the greater the heat resistance. With high fins the fin temperature is lowered, resulting in a loss in L.M.T.D.; hence the efficiency is lowered.

(4) *The fin-side coefficient.* As the fin-side coefficient is increased, the fin temperature tends to approach the temperature of the fin-side fluid. This is so because the resistance of the fin itself then becomes the controlling factor and becomes the thermal bottleneck. This results in a loss in L.M.T.D. and the fin efficiency is lowered. Ideally, the ratio of internal to external surface areas should be in inverse proportion to the coefficients.

(5) *Fin bond.* For a fin to be fully effective adequate contact between the fin and the tube is necessary.

Choice of Materials

To illustrate the effect of choice of material on cost, Table 2 gives a cost ratio for a few common materials used. Costs are given per square foot of external surface and it can be seen that plain copper tubing is the most expensive, while mild steel or copper tubing finned with aluminium fins are among the cheapest. Copper is an ideal material to use because of its high thermal conductivity, ease of manufacture and high corrosion resistance. However, because of copper shortages and prices other materials are being used.

With regard to the selection of the fans and motors, two main schemes are in use. For large air-cooled units either a number of small-diameter fans or a single large-diameter fan may be used. With large-diameter fans the supporting structure can usually be reduced and this tends to reduce costs. However, because fan speeds are necessarily low, a gearbox is required and the air-side pressure drop must be kept low. When operating conditions permit, two-speed motors are frequently used to facilitate temperature control and power savings. Finer temperature control can be effected with a multi-fan unit, and with the small, high-speed, fan-motor units a higher air-side pressure drop is allowable. In a typical air-cooler unit the fans are directly driven by motors within the ducts. There is usually a space between the fan and the tubes (the plenum chamber) and this has the dual effect of giving good air distribution across the finned tube section and of converting some of the velocity energy of the air leaving the fan to pressure energy. Sometimes a venturi ring at the inlet to the plenum chamber is employed, and this tends to decrease pressure losses.

Electric motors need not always be used and practically any form of drive can be adapted. Where the cooler is required for a diesel engine for example, the fan can be driven by the engine itself, if necessary via a belt-pulley system.

Arrangement of Tubes

Banks of tubes may be arranged vertically or horizontally as required. Units mounted vertically should be cheaper than those mounted horizontally, because of economy in steelwork construction. For large units the extended surface is usually arranged horizontally with the fan and motor mounted at ground or floor level. Another arrangement is to place the banks of tubes in the form of a polygon, with the fan in the centre inducing the air through the heat-transfer elements.

Some manufacturers prefer the induced - draught system for horizontal units, despite the fact that this entails mounting the mechanical equipment at a higher level. With

the induced-draught construction the velocity of air leaving the cooler is generally fairly high and this tends to reduce the possibility of recirculation. In some cases it may be desirable to inject the incoming cooling air with water to bring the air temperature down to the wet-bulb temperature when extra cooling is required. This process may be used for short periods of the year when the air temperature is excessively high and it is not economic to design to that temperature. With the use of water injection, a lower air temperature is achieved. The induced-draught air-cooler construction is suitable for the incorporation of water injection.

Cooling Elements

In cooling elements the finned tubes are usually arranged in banks with rows up to six deep. Fig. 8 shows a typical element prior to assembly. To prevent fin damage, and to allow free movement of the tubes, metal boxes which fit around the fins at intervals are provided. These also ensure proper tube spacing for maximum heat transfer. Tubes for this type of construction are usually expanded into the headers. Alternatively, they may be fitted by a screwed ring and packed gland joint—a method of construction that permits easy replacement of tubes but is prone to leakage.

Standard headers are made of cast iron or cast aluminium for low pressures, and of carbon or stainless steel for high pressures. Headers are designed to suit the duty and arrangement required, the number of passes, tube spacing, and number of tubes per header being varied appropriately. Easy access to the tube ends for tube cleaning and replacement may be effected by means of plugs. The box-type header with a removable cover shown in Fig. 8 is suitable for low pressures only.

When the tubes are welded to the headers, the headers can be made of a single pipe. This leads to a cheaper header, but, as with all welded header constructions, replacement of tubes is difficult and no internal mechanical cleaning is possible. Allowance must be made for thermal expansion of the tubes and with the usual straight-tube arrangement the tube bundle is fixed to the framework at one end only. Where the headers must be fixed at both ends the tubes are curved to allow for expansion.

Safety Considerations

Safety aspects of constructions must be studied and all moving equipment must be well guarded. With duct axial fan units a simple wire mesh over the free end is quite adequate. Large-diameter fan units are enclosed with wire mesh, and doors for access to the mechanical equipment are fitted with safety locking devices that ensure that the motor is switched off before maintenance men enter the danger area. A typical air-cooled unit which shows all the main component parts is illustrated in Fig. 9.

Cooling of Engines

The most well-known application of air coolers is that of cooling diesel and petrol engines. For mobile vehicles air cooling has been established as the only satisfactory method of cooling, but the use of air coolers for stationary installations, up to fairly recently, has been generally applied to low horse-power engines only.

Approximately one-third of the energy in diesel-engine fuel is dissipated as heat by the cooling system, so the choice of method of cooling should be considered carefully. The cooling-water circuit can be either an open circuit using water from a river or canal, or a closed circuit where the hot-engine cooling water is cooled in a heat exchanger with water or air as the cooling medium.

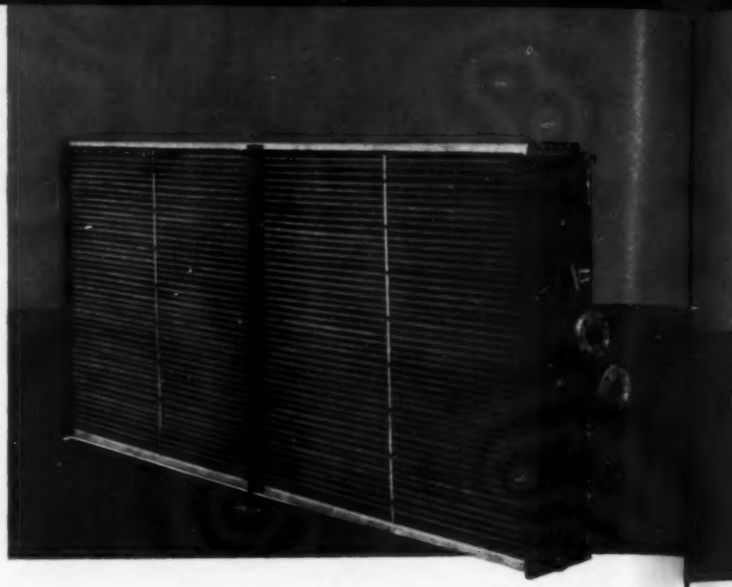


Fig. 8. A typical cooling element prior to assembly. To allow free movement of the tubes and to prevent fin damage, metal boxes are provided which fit around the fins at intervals. The box-type header shown is for use with low pressures only.

Advantages of closed-circuit systems, in particular those using air cooling, are as follows:

(1) Pure or treated water can be used and no scaling takes place in the system.

(2) Practically no water make-up is required. The only make-up water required is to compensate for possible leaks in the system, and therefore the cost of using treated water is not prohibitive as it would be with open-circuit cooling.

(3) When open-circuit cooling is employed, a layer of scale is gradually built up until it reaches a limiting thickness, at which stage the jacket must be cleaned. This means that the resistance to heat conduction is continuously varying, and to prevent overheating of the metal the cooling duty must be based on the worst conditions, that is, when the scale is at its maximum thickness. After the jacket has been cleaned, therefore, the metal will be cooled below the optimum temperature, with consequent increased wear on the piston rings and cylinder liners. The use of an air-cooled system, which avoids scaling, ensures constant operation at optimum metal temperatures.

(4) By using an air-cooled system, disadvantages of the open circuit, such as variation of water temperature from a natural source, restrictions by by-law on the use of natural water and possible recycling of water in the natural source, are avoided.

Two main air-cooled systems for engine cooling are employed. Either the jacket water and lubricating oil are cooled in separate sections of an air cooler, or only water is cooled by air, and an oil/water heat exchanger is employed. The first method eliminates the oil/water heat exchanger, and is particularly attractive if the coolers are to be situated near the engines; otherwise, the large volume of oil in the circuit can prove a disadvantage. Generally this system is to be recommended as it is usually advantageous to cool the fluids directly with air instead of *via* an intermediate exchanger. The tendency today is to run diesel engines hot. Among the positive advantages of high working temperatures are reduction in size and cost of the cooling equipment and in the formation of corrosive sulphur compounds which are the products of combustion of sulphur-containing fuel. It is

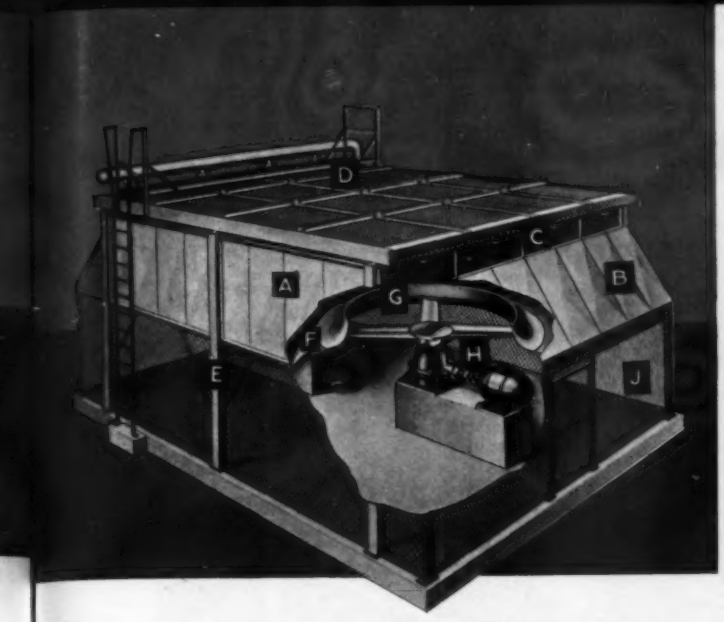


Fig. 9. Cut-away view of forced-draught air cooler showing arrangement of component parts. These are as follows: A, end wall; B, side wall; C, side-wall girder; D, heat-exchanger sections; E, columns; F, plenum chamber; G, venturi ring; H, fan, gear and driver; and J, safety fencing.

thought that a main cause of liner wear is the corrosive properties of these sulphur compounds, and it is only by keeping the temperatures of the cylinder walls and cylinder head high that their production can be avoided.

Lubricating-oil coolers should be operated at as high a temperature as possible to gain the advantage of better heat-transfer conditions. The reduced viscosity also keeps down the pressure drop of the oil and allows higher velocities. The upper limit for the temperature of lubricating oil is restricted by the limiting operating conditions for the maintenance of a satisfactory oil film. With the continued research on lubricating oils and the introduction of detergent oils, higher engine working temperatures can be achieved; indeed, lubricating-oil temperatures as high as 180°F have been successfully maintained. Engine-water temperatures from 180°F to 150°F are now being specified, and with these temperatures economic air-cooled heat exchangers can be designed. Developments using steam to cool engines have taken place and it is possible that, in future, engines will be run at even higher temperatures.

Examples of Air Coolers

In a typical installation of horizontal cooling, elements for cooling water from a diesel engine station that has an approximate rating of 12,000 bhp, the coolers dissipate 23×10^6 Btu/hr at an approach of 40°F to the dry-bulb temperature. Each cooling element is independent in operation and can be taken out of circuit or put on stream as required by process considerations. Sections can also be shut-down for inspection and maintenance whilst keeping the main part of the unit in operation, and this facility is vital where continuous running is of importance. Horizontal units are also available with the tubes fixed into box-type headers. The header covers are readily removable for inspection and maintenance of the tubes.

Another form of construction for diesel-engine cooling is an "A"-type structure. Banks of finned tubes are arranged horizontally, and the headers are placed along the slant height at each end. The fans are situated within the structure and air is drawn from the base and forced over the finned tubes. This kind of construction has also been used for air-cooled condensers, but for this application one steam-inlet header is placed along the top of the unit and the banks of finned tubes are arranged along the slant height of the construction. Steam enters the finned tubes at the top and is condensed, and the condensate is collected in smaller headers at the bottom end of the tubes, whence it is pumped to the boilers.

Condensing Steam from Turbines

Air-cooled condensers to condense steam from turbines in power generators are being used for both mobile and stationary sets. Most mobile sets are equipped with air coolers, and thereby, are made independent of water supplies. In small, mobile generating sets, suitable for mounting on trailers, the engine is cooled by a forced-draught vertical air-cooled heat exchanger. The fan, driven by the diesel engine, forces air across banks of finned tubes in which lubricating oil and jacket water circulate. Air flow is controlled by hand-operated shutters which can be used for temperature control and rapid warming of the engine during the winter.

Larger mobile condensing units are usually mounted on railway wagons, and here the duty is usually to condense steam from turbines. Power trains are often expected to work in ambient temperatures between −40°F and +95°F, and the prevention of freezing requires considerable attention. Units designed for low ambient temperatures are arranged so that steam and condensate are in counterflow. This not only prevents freezing, by heating the condensate, but it tends to de-aerate the condensate. It is essential to balance the steam flow to the sections of the condenser, as this gives good heat-transfer conditions and also removes the danger of freezing. A stationary air-cooled unit which condenses about 40 tons an hour has been made in Germany. The finned-tube elements of the plant are arranged in a hexagon shape with two fans inducing air through the finned elements. The fans are situated at a level slightly above the finned elements and at the base of two chimneys, which, themselves, provide natural draught and also serve to prevent recirculation of air by ejecting hot air at a high level.

(To be concluded)

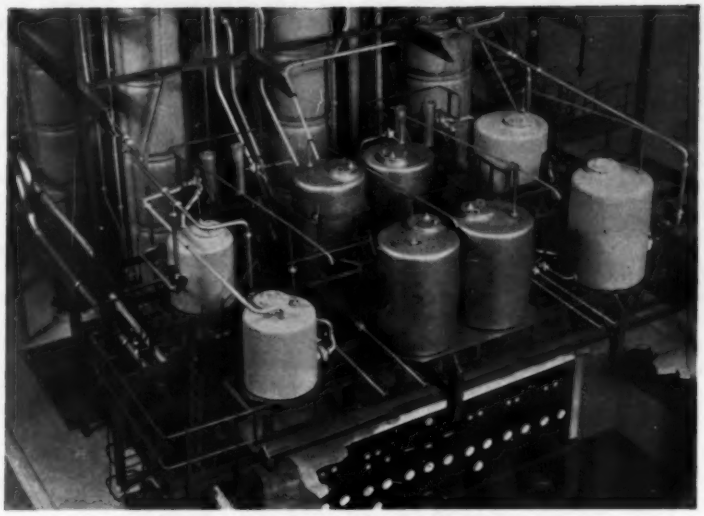
N.C.B.'s New Carbonisation Plant

The new Avenue Chesterfield carbonisation and chemical plant of the East Midlands Division of the National Coal Board was opened by Mr. Aubrey Jones, Minister of Fuel and Power, on October 30. In a speech after the ceremony, he spoke of the Coal Board in its capacity as a converter of coal into products of wider usefulness. That aspect of the Board's activity was likely to become even more important in the future than it had been past, he said. In the manufacture of solid smokeless fuels, which would come increasingly into demand, the Board had a special part to play. Currently, extensions were nearing completion which would double the capacity of the Board's Phurnacite plant in South Wales for processing bituminous coal. He further stated that the coke produced at the plant he had just opened was of the domestic and industrial kind, although metallurgical coke could be made there if necessary.

Mr. James Bowman, chairman of the National Coal Board, commended the plant as a sound investment in fuel efficiency; as the source of "innumerable useful products"; and as a "symbol of the Board's determination to live up to the expectations which the country placed in them when Parliament decided that the coking plants of the old colliery companies should be vested in the Board".

Continuous Distillation of Tar Acids

The technique of tar-acid distillation has been advanced by the starting of a new plant at the North Thames Gas Board's Beckton works



View of the model presented to Science Museum, showing fraction tanks and control room.

THE new continuous tar-acid distillation plant now on stream at the Beckton by-products works of the North Thames Gas Board contains a number of novel chemical engineering features. The plant, the largest completely continuous tar-acid distillation assembly in Europe, and possibly in the world, has been designed continuously to dehydrate and depitch crude acids obtained from various sources under the Board's control, and to separate, as commercially pure fractions, phenol, *o*-cresol, *m*-*p*-cresol and xylenols, leaving a residue of hard pitch. The capacity is 3640 lb./hr, and steam at only 300 psig is used as heating medium.

The plant is divided into two main sections with 24-hour balance tanks between them to enable either section to run independently. The sections are: (a) "once-running plant", comprising dehydration column, primary cutting column ("once-running" column) and pitch stripper; and (b) "pures plant", consisting of a two-part phenol column, *o*-cresol column, *m*-*p*-cresol column and product tanks. The entire plant is operated under vacuum, produced by duplicate two-stage steam ejectors.

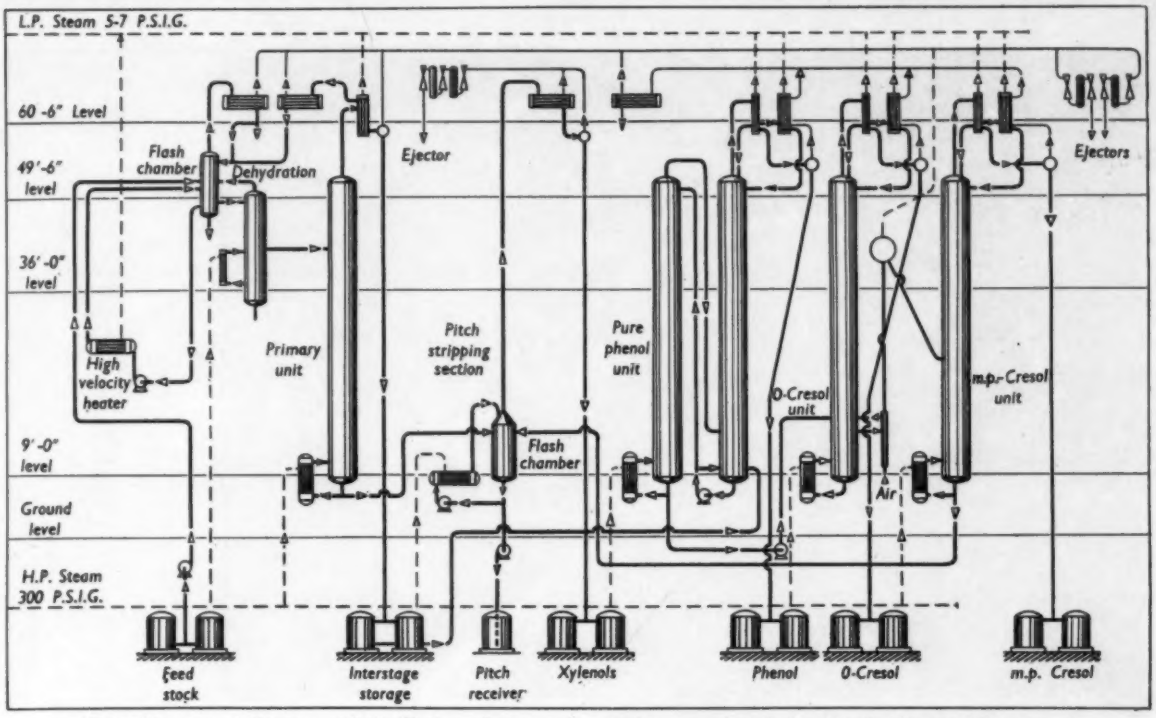
Special features of the plant include the dehydration and pitch-stripping units. The dehydration unit is in two sections. In the first, dehydration takes place by flashing in a vessel that is sufficiently large to ensure adequate separation of the sodium sulphate present in the crude feed. The heat source is low-pressure steam, and the heat is transferred to the process fluid in a high-velocity heater designed to avoid fouling. The second stage is a stripping process which removes the last traces of water from the acids. High-pressure steam is the heat source, and the heat is transferred to the process materials in an external, natural-circulation evaporator. The dehydrating columns used in both stages are built of hood-type non-fouling plates fitted with hand-holes.

In the "once-running" column, pitch and xylenols are separated from the lower-boiling phenols. The pitch and xylenols mixture leaving the base of the primary unit is passed to a jacketed evaporator, and the xylenols are evaporated by forced circulation through a high-velocity, high-pressure steam heater. The residues from the "pures" columns which contain xylenols are also fed into the evaporator. The separated xylenols pass in one fraction through the vapour pipe, and the pitch, at a specified viscosity, is removed by an extractor pump. The pitch is then mixed with creosote oil and is used as fuel. The refined products are made in the second sequence of fractionating columns, each containing West distillation plates fabricated in mild steel. The top section of each column, together with product-condensers and tanks are constructed in stainless steel to reduce the development of colour in the finished products.

The evaporative condensers enable a substantial quantity of the primary heat to be recuperated in the plant as low-pressure steam (5-7 psig). This enters a low-pressure header and is used for dehydration, steam tracing and jacketing of the plant. Excess steam above these requirements is passed out of the plant and may be used for other low-temperature duties. Vacuum, rate of feed and main steam-pressure supply to the reboilers are automatically maintained, but product withdrawals according to specification are manually set. All controlling operations are carried out remotely from a centralised panel. The ejectors are controlled by independent instruments and provision is made for either ejector to maintain the necessary 25-in. vacuum in the event of failure of the other. The pitch-stripping plant operates under a lower pressure than the remainder of the plant. Liquid levels in the base of the columns are controlled by Drayton regulators pneumatically operated.

The plant has been designed to operate with a 10% overload in any component, but if the composition of the crude feed alters beyond that limit the plant can still function with a lower throughput. The designed capacity is 4000 lb./hr. Table 1 summarises the design and test figures of the plant. Table 2 shows the composition of the crude feed stock.

The new plant replaces a smaller batch plant and is



Flow diagram of the tar-acid distillation plants at the Beckton works of the North Thames Gas Board.

housed in the building, suitably extended, which formerly accommodated the older installation.

A model of the new plant, built at the suggestion of the Association of Tar Distillers, has been presented to the Science Museum, London. Built to a scale of $\frac{1}{4}$ in. to 1 ft, it was handed over by the A.P.V.Co. Ltd. at a ceremony held in London on October 16. It will form a permanent part of the display in the new organic industrial chemistry gallery at the Museum. The presentation was made by Dr. R. Seligman, chairman of A.P.V., and the model was accepted by Dr. T. C. S. Morrison-Scott, director of the Museum. It is 3 ft wide by 3 ft high by 1 ft 9 in. deep and took one and a half years to build.

Still house showing left, phenol rectification and stripping columns and, right, the o-cresol column.

Table 1. Summary of Design and Test Figures

Throughput	*Design*	*Test*
Crude feed ...	350 gal./hr	350 gal./hr
Services		
Steam 300 psig ...	3.5 lb./hr crude	2.9 lb./hr crude
Power (kW) ...	25.0	16.7
Products		
Phenol — cryst. point	40.0°C	40.3°C
High *o*-Cresol fraction ...		
o-Cresol ...	90.0%	93.5%
Phenol ...	5.0%	0.8%
m-p-Cresol fraction		
m-Cresol ...	55.0%	55.8%
o-Cresol ...	2.0%	1.3%
Xylenols ...	—	I.B.P. 211°C
Pitch, softening point R and B	80°C	80°C

Table 2. Composition of Crude Feed Stock

Constituent	*Approximate Percentage*
Water	12
Phenol	25
o-Cresol	9
m-p-Cresol	28 (*m-p*-ratio 60:40)
Xylenols	17
Pitch	7
Neutral oils, tar bases and additional compounds...	Not more than 1

Aerial view of the 18 mist precipitators at the United Sulphuric Acid Corporation's plant at Widnes.

ELECTRO-PRECIPITATION—

A METHOD FOR THE RECOVERY OF PROCESS FUMES AND DUST

This article deals with the theory and practice of electro-precipitation, a method which is acknowledged to be the most efficient and often the only means of recovering process fumes and dust

by Dr. R. F. HEINRICH and J. R. ANDERSON, A.M.I.E.E.

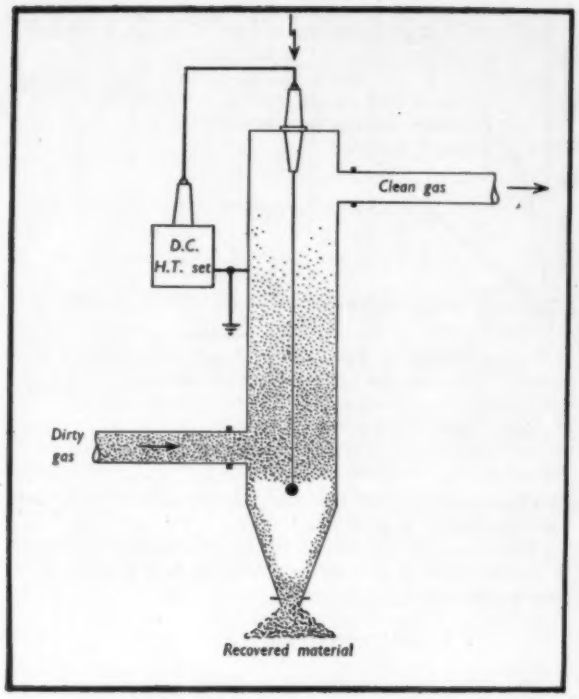
IN Britain very little published information is available on electro-precipitation compared with the U.S.A. or Germany, in which countries the process has been adopted and practised for some time. Yet the basic principles of electro-precipitation are known to nearly all schoolboys who are taught that by rubbing a piece of amber it is possible to attract suspended particles from the air and cause them to settle by the aid of electrical forces. This same phenomenon is used in electro-precipitation to remove solid or liquid particles from a gaseous-carrying medium by giving the particles an electric charge and precipitating them on to a receiving surface in an electric field.

Tubular-type Electro-precipitator

An electro-precipitator consists, basically, of a round tube through which the gas and dust pass; a wire suspended in the tube axis to set up a corona discharge; a current of high tension (H.T.) to supply the electrical energy; and a hopper to catch the precipitated dust when it falls by gravity off the tube's inner surface (see Fig. 1).

The tube would be 6 to 10 in. in diameter by 10 to 12 ft long. The wire would be $\frac{1}{8}$ to $\frac{1}{4}$ in. thick, whilst the H.T. set would give unidirectional current of negative polarity of around 1 mA at 30 to 60 kV. The gas is ionised by the effect of the strong electric field in the immediate vicinity of the ionising wire when a sufficient potential is applied to set up the corona or brush discharge. In the corona, ionisation by collision produces negative electrons as well as positive and negative gas ions in large quantities—approximately 10^6 per cm^3.

The ionising wire is generally at negative polarity (since the negative corona is more stable than that of positive) and this allows the use of higher tensions on the ionising wire. It also allows for a higher field intensity before electrical break-down in the air space between the wire and the tube which is at positive polarity and connected to negative or "earth". With negative on the ionising or discharge electrode, the positive gas ions are attracted at high speed towards the discharge electrode and are there neutralised. The electrons and negative gas ions, on the other hand, are repelled by the negative discharge electrode and move towards the positive tube wall at a high speed (over 60 m/sec. in air at 20°C) to give up their charges on meeting the tube surface. The electrons and ions fill the space between the discharge and receiving electrode as a negative space charge.



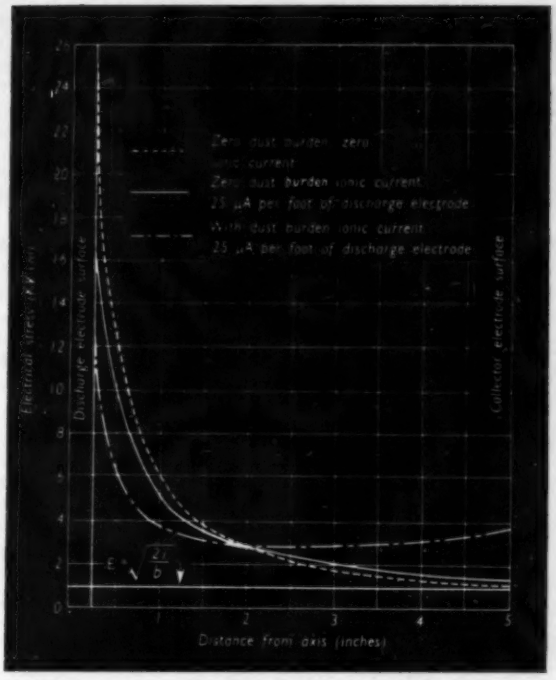

Zero dust burden zero ionic current
Zero dust burden ionic current 25 μA per foot of discharge electrode
With dust burden ionic current 25 μA per foot of discharge electrode
Discharge electrode surface
Collector electrode surface
Distance from axis (inches)

Fig. 1 (left). Schematic arrangement of single-stage tubular-type electro-precipitator. Fig. 2. Field distribution in a tube-type precipitator. The dotted line represents zero dust burden, zero ionic current. The full line indicates zero dust burden, ionic current 25 microamps per ft of discharge electrode. The chain dotted line shows conditions with a dust burden, and ionic current of 25 microamps per ft. T, the dust surface area per c.c. of gas, is 0.083 cm^{-1}, and V is 40 kV.

As the dust-entrained gas flows up the tube the particles absorb electrons and ions from the negative space charge due to the action of the electric field and the thermal agitation and diffusion motion of the ions. The entrained particles become negatively charged almost to their maximum limit, attaining this charge in a fraction of a second.

In general, there are only about 10^3 to 10^5 suspended particles per cm^3 present in the gas compared with around 10^9 ions and electrons per cm^3; thus, the latter greatly predominate. The number of gas molecules per cm^3, on the other hand, is in the region of 10^{19}, so that only a small percentage of the gas molecules are ionised. Depending on the particle size, their charge, the average field strength and the gas viscosity, the suspended particles move at a velocity between 2 to 50 cm per sec. towards the receiving electrode where the particles adhere under the electrical and molecular forces and give up their negative charge. When the deposit reaches a certain thickness it either falls off under gravity or is rapped off mechanically and collected in the dust hopper below the tube. The gas, cleaned of its entrained particles, passes on out of the tube.

Plate-type Electro-precipitators

Plate-type electro-precipitators work on the same principles as the tubular type. In place of tubes, flat, upright panels are used to form gas-passes between parallel mounted plates. The discharge electrodes are suspended centrally between the pairs of receiving electrode plates. The size of a precipitator to suit a given set of conditions can be arrived at by use of the Deutsch[1] formula expressed as:

$$y = 1 - e^{-k} \qquad \ldots . (1)$$

where $y = eff$, k=exponent, and e=naperian log base.

This expression, of course, is only valid for the theoretically ideal conditions based on the assumption that all dust which reaches the receiving electrodes also adheres to them, and that no disturbances in the precipitating conditions occur, e.g., through the insulating effect of the coating of dust on the electrodes.

The constant k can be expressed in various terms according to practical requirements, as for instance:

$$k = wF \qquad \ldots . (2)$$

$$k = w\frac{2L}{Rv} \qquad \ldots . (3)$$

$$k = w\frac{L}{Dv} \qquad \ldots . (4)$$

$$k = w\frac{SL}{Qv} \qquad \ldots . (5)$$

$$k = w\frac{SL}{G} \qquad \ldots . (6)$$

where k = exponent;
w = migration velocity (m/sec.);
F = specific collecting surface (m^2/m^3/sec.);
L = length of collecting electrode in direction of gas stream (m);
v = gas velocity (m/sec.);
R = radius of receiving electrode tube (m);
D = space between discharge and collecting electrodes (m);
S = active circumference (m);
Q = cross-sectional area (m^2); and
G = volume rate of gas flow (m^3/sec.).

It will be seen that the constant k consists of two terms; namely, the migration velocity w and a set of factors designating geometrical dimensions and gas velocity v.

The most general of the above expressions is (2): in this, since w has the dimensions of a velocity, F has those of an inverse velocity, but if suitably enlarged as proposed[2] it attains a rational meaning:

$$F\,(\text{sec./m}) = F\,(\text{m}^2\text{sec./m}^3) = F\left(\frac{\text{m}^2}{\text{m}^3/\text{sec.}}\right) \qquad \ldots.(7)$$

The last of these dimensions suggests that F constitutes a "specific collecting surface", that is, a certain collecting surface per unit volume of gas treated per second.

Equation (3) holds good for tube-type and Equation (4) for plate-type precipitators. Equation (5) is useful for calculating the size of a precipitator using other than cylindrical tubes, and Equation (6) is useful for calculating the required circumference of a receiving electrode for a given gas volume and a standard receiving electrode length.

Migration Velocity w

Having dealt with the second of the terms appearing in the expression $k=wF$, detailed consideration will now be given to the factor w, the average migration velocity of the particles in the electric field. Assuming ideal conditions, the migration velocity of a particle is proportional to its charge and the electric field strength.

$$w \propto q\,E_c \qquad \ldots.(8)$$

where q (stat. C) = particle charge; and
E_c (stat. V/cm) = field strength.

The charge acquired by a particle can be calculated by assuming two different mechanisms to be involved[3]: the charging of particles by ions in an electric field of field strength E_i and the charging of particles due to the thermal movement of the gas ions. In the first case the maximum charge n_m on a particle will be:

$$n_m\varepsilon = f E_i r^2$$
$$f = 1 + 2\,\frac{\delta - 1}{\delta + 2} \qquad \ldots.(9)$$

where n (—) = number of elementary charges;
ε (stat. C) = elementary charge;
E_i (stat. V/cm.) = field strength;
f (—) = factor; and
δ (—) = dielectric constant.

This formula is commonly used for particles over about 2 microns diameter. For smaller particles the charge due to the thermal motion of the particles will be predominant, although both mechanisms will apply. For this second case, Ahrendt and Kallmann[4] have developed an equation, and Ladenburg[3] has shown that for practical purposes the following equation is a good approximation:

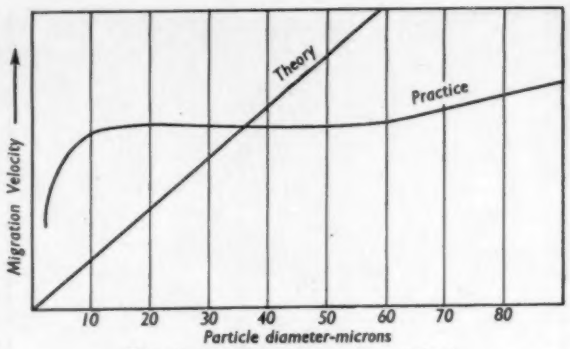


Fig. 3. Relation between partical diameter and migration velocity.

$$n\varepsilon \simeq 2.10^6\,r \qquad \ldots.(10)$$

where r (cm) = radius of particle.

Further formulæ for the charging of particles are given in a paper by Walker.[5]

The migration velocity is further determined by Stokes' Law, modified in that the gravitational field is replaced by the electric field.

$$w = \frac{n\,\varepsilon\,E_c}{6\,\pi\,\eta r} \qquad \ldots.(11)$$

where η (poise) = absolute viscosity.

Expression of the charge by means of Equations (9) and (10) gives respectively:

$$w = \frac{f E_i E_c\,r}{6\,\pi\,\eta} = \frac{f E^2 r}{6\,\pi\,\eta} \qquad \ldots.(12)$$

$$w = \frac{E_c\,10^6}{3\,\pi\,\eta} \qquad \ldots.(13)$$

For larger particles, to which Equation (12) applies, the migration velocity is proportional to the radius of the particles. It is also proportional to the square of the field strength, since in a conventional electro-precipitator the charging or ionisation field strength E_i is the same as the field strength E_c in the collecting zone.

The field strength around a thin wire emitting corona discharge is given by the equation:

$$E = \sqrt{\frac{2i}{b} + \left(E_a \cdot \frac{a}{d}\right)^2}$$

$$E_a = 103 + \frac{31.8}{\sqrt{a}}\ (\text{stat. V/cm}) \qquad \ldots.(14)$$

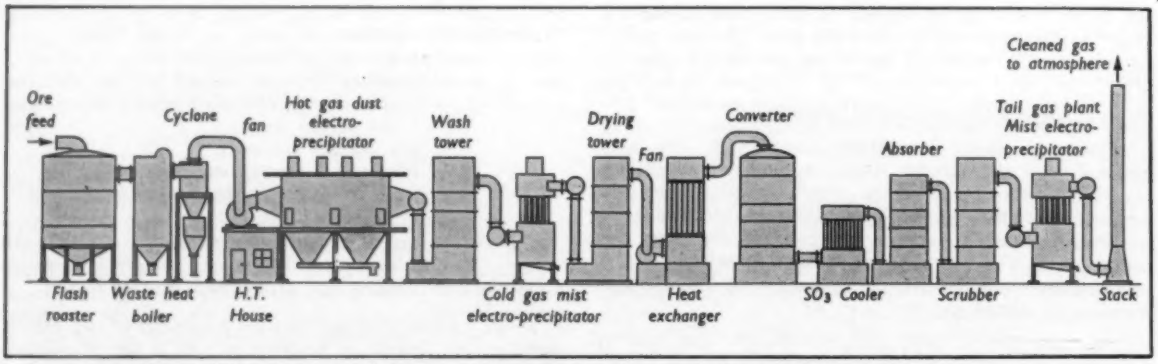


Fig. 4. Flow diagram of a gas purification plant for producing sulphuric acid from pyrites.

where i (stat.A/cm) = current per unit length of discharge wire;
b (cm/s/stat.V/cm) = mobility of ions;
E_a (stat.V.cm) = corona starting field strength;
a (cm) = radius of discharge wire; and
d (cm) = distance from centre of discharge wire to point in the field.

For thin wires this reduces essentially to:

$$E = \sqrt{\frac{2i}{b}} \qquad \ldots\ldots(15)$$

From (15) and (12) follows:

$$w \propto i \qquad \ldots\ldots(16)$$

If charged dust is present in the space between the electrodes an additional space charge is set up which levels out the field strength near the discharge electrode and increases it near the collecting electrode; according to Lowe and Lucas,[6] the field strength is then given by the equation:

$$E = \frac{1}{d}\left[\left(\frac{i}{bf^2T^2} + C_o^2\right)\exp(2fTd) - \frac{2i}{fTb}\left(d + \frac{1}{2fT}\right)\right]^{\frac{1}{2}} \qquad \ldots\ldots(17)$$

where T = total surface area of dust per cu. cm of gas (cm^2/cm^3); and
C_o = constant of integration (stat. V).

Fig. 2 shows field gradient curves for various conditions as given by Lowe and Lucas.

Calculation of the field strength according to Equation (15) gives the lowest value corresponding to the field strength at the receiving electrode produced by the static field from the discharge electrode without any dust burden. With ionic current flowing, the field strength near the receiving electrode is slightly increased, but the increase becomes pronounced when there is dust burden as well as ionic current flow. If the dust burden, or rather the surface area of the entrained particles, becomes excessive, a large space charge of low mobility is built up by the charged fine fume particles surrounding the discharge electrode under such conditions. The field gradient near the discharge electrode may be reduced so greatly that the corona current will be lowered considerably, and much higher voltages must then be used in order to overcome the quenching effect. Since the decisive factor is the total surface area of the entrained particles, it is clear that quenching is especially likely when the particles are very small since, at any given concentration by weight, the smaller the particles, the greater the total surface area: the effect of small particle size is notable, for instance, in fume precipitators, in which a concentration as low as about 0.1 grain per cu. ft may be enough to cause substantial corona quenching.

From the foregoing formulæ the efficiency of a precipitator can be calculated, on the important assumption that the particle size distribution is known, since efficiency under given conditions is different for each size of particle. Such calculations have been made, and the theoretical results have been compared with the results of tests under laboratory conditions.[7,8] The close agreement observed suggests that it is unnecessary to introduce the effect of the so-called electrical wind developed in corona discharge into collection formulæ applied to precipitators of present-day design. It should, however, be noted that particle migration velocities much higher than those expected from calculation have been actually measured by Ladenburg,[3] a fact which he attributes to the electrical wind. The action close to the electrode surface, however, could not be clearly observed and it appeared that dust particles came to rest or reversed their direction of motion. No definite statement of the real effect of the electrical wind was made therefore, nor was it indicated how such an effect should be embodied in calculations of precipitator efficiency.

It is apparent from the efficiency formula that a given efficiency requires a larger specific collecting surface for small particles than for large ones, and it follows that, when extrapolating performance data from one precipitator to another working under similar conditions, regard must be made to particle size distribution. For the same reason, different values of w will be obtained when assessing this factor in a precipitator designed for say 90% efficiency and one designed for 99% efficiency under

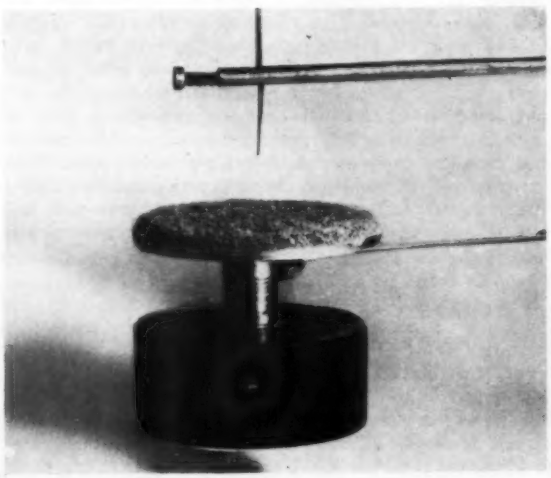


Fig. 5. Point-to-plate apparatus for investigating the phenomenon of back ionisation.

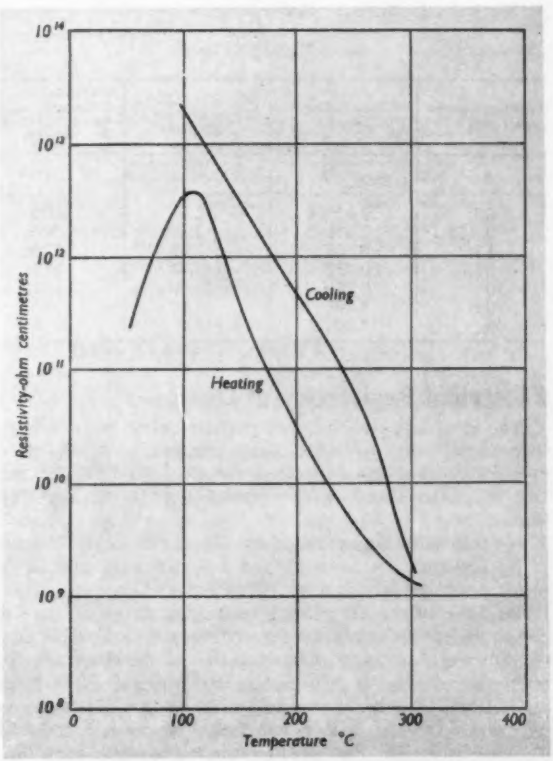


Fig. 6. Dust resistivity against temperature °C.

identical conditions. The average migration velocity w will be lower in the latter case, because more of the finer particles will be precipitated. Nevertheless, the introduction of the migration velocity w into industrial practice in the early stages of electro-precipitation made it possible to compare different installations on a common basis.

A phenomenon which seems only to have come to light fairly recently is that migration velocity is not, in actual practice, proportional to particle size as stated in Equations (12) and (13). At present it can only be assumed that this is due to something that happens after the particles have been precipitated, possibly the preferential re-entrainment of the larger particles, as suggested by Lowe and Lucas.[6] The curve in Fig. 3, which is based on actual test results,[9] shows that small particles appear to be precipitated at a greater rate than is suggested by theory: this may possibly be due to small particles attaching themselves to larger ones or to their agglomerating into large particles.

In the intermediate range of particles between about 10 and 60 microns, the migration velocity is almost constant, though it is found to rise slightly for the larger particles: this, however, is only the case when high-duty electrodes are used, as they were in the tests from which Fig. 3 was derived; the use of flat plate electrodes results in decreased migration velocity indicated by lower collection efficiency.[10] This seems to support the theory of Lowe and Lucas that large particles are more easily re-entrained than small ones, because they agglomerate less readily and firmly and are held to a plate electrode by less powerful molecular forces. On the other hand, the discrepancy between theory and practice is so wide that there may well be additional reasons, such as less effective charging, for the less efficient removal of large particles.

The following table[11] gives an idea of the comparison between the theoretical migration velocities of charged particles in an electric field and the free-falling velocity of the particles in the gravity field.

Table 1

Particle Diameter (spec. grav. 2.7)	Free Falling Velocity	Migration Velocity in Electric Field of 3000 V/cm	Migration Velocity N Times Greater than Free Falling Velocity
μ	cm/s	cm/s	N
0.1	0.00008	2.8	35,000
0.2	0.00032	2.8	8,700
1	0.008	2.94	370
2	0.032	5.88	183
10	0.80	29.40	32.6
20	3.20	58.80	18.3
40	13.20	117.60	8.9

Electrical Resistivity of Dust

The electrical resistivity of particles plays an extremely important part in electro-precipitation. Variations in resistivity cover the enormous range of 10^{-3} to 10^{14} ohm cm, a range which may conveniently be divided into three:

(a) resistivity below about 10^4 ohm cm;
(b) resistivity between 10^4 and 2×10^{10} ohm cm;
(c) resistivity above 2×10^{10} ohm cm.

Particles of the very low resistivity of range (a) give up their charge almost instantly on reaching the electrodes, whereupon they assume the polarity of the electrode and are repelled from it into the gas stream again: the larger particles, which are not firmly held to the electrodes by molecular forces, are particularly prone to "hop" or "creep" through the precipitator, a phenomenon well known in older types of boiler flue dust precipitator when there is more than a certain percentage of highly conductive carbon in the ash.

Resistivities in the intermediate range (b) are the most suitable for electro-precipitation. Those in the high range (c) give rise to phenomena which may seriously upset precipitator performance.

Back Ionisation

The principal phenomenon caused by dust of high resistivity is the onset of "back discharge" or "back ionisation"; in other words, the creation of positive ions in the dust layer on the receiving electrodes. This is caused by electrical break-down of the dust layer, which takes place because the highly insulating dust will not allow the particle charges to drain through it: a high potential is therefore built up on the outer layer of dust facing the discharge electrodes, and this potential may rise to a point at which electrical break-down occurs in the gas filling the interstices between the dust particles. In this event the emission of positive ions converts a point-to-plate spark gap into a point-to-point spark gap, which is known to break-down at much lower voltages, and it becomes impossible to raise the precipitator voltage high enough to give a sufficient current output. It can be seen from Equations (15), (12) and (13) that the current is proportionately related to the migration velocity and therefore controls the efficiency of particle removal: if the current is too low the efficiency will be low.

Fig. 5 shows the point-to-plate apparatus used. According to Mierdel and Seeliger,[12] who have done much work on the fundamental aspects of electro-precipitation, back ionisation is related entirely to electrical stress in the interstices of dust pores which are breaking down electrically, and is not associated with points protruding from the dust layer.

The undesirable phenomenon of back ionisation can only be prevented by conditioning the dust so as to reduce its resistivity below the critical point. White[13] has done much field work in this respect and has found sulphuric acid to be one of the most effective conditioning agents; ammonia is also used in some cases. Field tests by White also indicated 2×10^{10} ohm cm as the borderline between resistivity ranges (b) and (c); resistivities of 5×10^{10} ohm cm or more are virtually certain to cause trouble.

The difficulties caused by high-resistivity dust have been known for a long time, and in plants for cleaning blast furnace gas, for instance, they have been successfully overcome by using humidifying towers. These difficulties, however, are nowadays encountered in a severe form, and to an increasing extent, in precipitation plants for cleaning the flue gases of modern pulverised-fuel-fired boilers. The troubles on earlier plants for this purpose arose because the percentage of highly conductive carbon in the ash was, if anything, too high, but the opposite is now the case. In modern boiler furnaces not only is combustion substantially complete but temperatures have also increased, giving rise to highly non-conductive silica fumes: other factors controlling the conversion of SO_2 into SO_3 also have their influence, and if conversion is insufficient the strong action of the conditioning agent SO_3 is reduced.

Fig. 6 shows typical curves of dust resistivity.[14] The lower curve shows that when the dust is heated the resistivity increases to a peak and then diminishes at higher temperatures. The rising portion of this curve is determined by the moisture absorbed in the dust surface: this moisture, possibly together with other conditioning agents, is driven off as the temperature rises, and after reaching the peak value the resistivity begins to fall owing to increasing thermal conductivity. The upper curve shows that when the dust is cooled the resistivity is high at the

upper temperature range owing to loss of moisture which has not been recovered. These phenomena may be important in some cases.

Particle Re-entrainment

If dust is poured from a window at some height above ground, it is obvious that little of it will reach the ground perpendicularly below the window in even the slightest wind. Conditions obtaining in electro-precipitators are very similar; the collecting electrodes are 10 to 20 ft high, dust is collected from top to bottom of them, and when the dust is dislodged by rapping it is highly unlikely that all of it will reach the hopper without some re-entrainment. If the gas velocity is high, re-entrainment may also occur during the actual precipitation process due to erosion of particles from the collecting surface. It is obvious that re-entrainment must decrease the efficiency of a precipitator. Its direct result is a reduced migration velocity w, because w is the only variable in the efficiency formula which takes account of decreased efficiency under otherwise identical conditions. In the event of re-entrainment, w no longer has its literal meaning, but is "degraded" to a mere operation factor. It is still useful, however, to call this factor migration velocity because the term creates a mental image more easily appreciated than a mere numerical factor. Apart from this, it obviously remains true that the reduced migration velocity represents the average velocity with which particles are precipitated, allowing for those which are re-entrained.

The extent to which dust is re-entrained can be reduced appreciably by adopting the correct design for the collecting electrodes. Spectacular improvements were achieved in the early 1920s, when the so-called catch-pocket-type duty electrodes were invented. The design of these electrodes arose from the problem of cleaning the flue gases from lignite-fired boilers, the gases passing through an existing flue at a velocity of about 14 ft/sec. It was found impossible to obtain the guaranteed efficiency with the wire mesh screens which were used as collecting electrodes, but the problem was solved by the development of electrodes which collected the particles in such a way that they could fall into the hopper through a quiescent zone, undisturbed by the eroding effect of the gas stream. With wire mesh electrodes w had a value of the order of 4 cm/s at about 15% overall efficiency, whereas with the design of high-duty electrode finally adopted the value of w rose to 51 cm/s at about 98% overall efficiency under otherwise identical operating conditions. It is interesting to note that the theoretical migration velocity calculated for the prevailing conditions and particle size distribution was 65 cm/s. From this it is evident that, whilst re-entrainment can be considerably reduced, the theoretical migration velocity still differs from the velocity calculated from the measured efficiency and physical dimensions of the precipitator.

Precipitator designs can only be based on values of w found in actual tests. Designers nowadays know from long experience what values of w can be used under given operating conditions and with given types of collecting electrode, so that the effects of re-entrainment are no longer a serious problem, except where flat plate receiving electrodes are used with gas velocities over 3 ft/sec.

Recent developments[15] have proved that re-entrainment can be still further reduced with the use of so-called chute electrodes which give even higher migration velocities than the catch-pocket type under identical operating conditions.

Conclusion

It has been seen that there are basic equations from which certain calculations for precipitator design can be made. There are, however, secondary influences, such as the re-entrainment of particles and their electrical resistivity, which in some cases may be so pronounced as to mask entirely the physical laws relating to the ideal process of electro-precipitation: the effect of these influences on efficiency of particle removal cannot at present be expressed mathematically. There are also indications that the performance of electro-precipitators is affected by other factors not yet fully explored.

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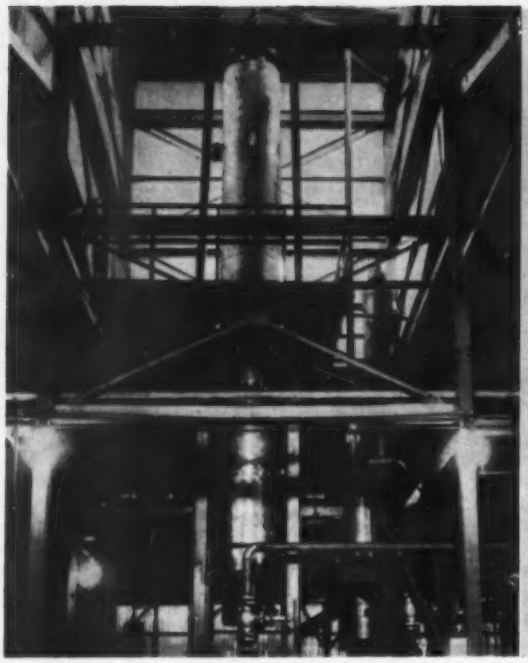
ISOTOPES SEPARATED IN BRITISH PLANT

THE first commercial isotope separation column in the world is now being operated by a British firm, 20th Century Electronics Ltd. This prototype plant for the production of Boron 10 (an essential factor in atomic energy research) is the result of intensive collaboration between the scientists of the U.K.A.E.A. and the firm's technical staff.

The column, a narrow tube intricately packed with five miles of stainless steel wire, is suspended centrally in a giant metal vacuum container in order to avoid heat losses. It weighs, together with control equipment, several tons and costs in the region of £2000 per foot. The raw material is heated at the base and the product is then passed through the column, whose temperature gradient throughout its length is closely controlled. The final condensate, a colourless liquid, is taken off at the rate of a droplet every few minutes, the total output being a pint a month.

Boron 10 is one of the most efficient media for the identification and measurement of neutrons. In its elemental form, Boron can be used mostly effectively as a protective screen for atomic-pile operators because of its extraordinary power of annihilating all neutrons within its path.

The Boron 10 produced has an enrichment of over 99%, 12% more than the experimental column exhibited by the Russians at the "Atoms for Peace" Exhibition held at Geneva last year. A further by-product of the British column is Boron 11; again of great value in nuclear research. At present the total production of Boron 10 is barely sufficient to meet the needs of Harwell, but the firm plan the construction of several other columns of greater heights.



Ore reduction vessel before insulation. (Photo: Hydrocarbon Research Inc.).

FLUIDISED METALLURGY AND H-IRON

Fluidisation opens up the prospect that certain metallurgical processes could be rendered continuous instead of being dependent on batchwise operations. This article follows up the interest created by the announcement of the H-iron process and the Cyclo-steel process ("British Chemical Engineering", October 1956, p. 291), and reviews what has already been done and what is in this new field of application for chemical engineering.

FLUIDISATION technique primarily involves a method of bringing about contact between a gas and a solid. It is therefore a method full of promise for the exploration of reactions involving *either* the treatment of gases with a solid catalyst *or* the chemical treatment of a solid with some reacting gas. The early field of expansion of fluidised processing was in connection with the catalytic cracking of petroleum fractions. However, the wider field of application would seem to be in connection with the chemical treatment of solids, and, in particular, with the processing of ores and metal compounds with a view to producing suitable metal powders ready for some finishing or shaping operation.

Chemical engineering has made a number of additions to the operating techniques of extraction metallurgy, itself only a branch of applied chemistry, although many metallurgists are unwilling to accept this view. Such important techniques as liquid/liquid extraction and ion exchange have greatly dominated the development of the metallurgy of materials used in the nuclear energy programme. But the Metallurgical Editor of *Iron Age*[1] has chosen to comment particularly upon a process based on fluidisation technique, the reduction of iron oxide with hydrogen. The production of H-iron, according to him, could prove to be one of chemical engineering's major contributions to the metals industry. The recent gradual, but extremely forceful, infiltration into territory that was almost exclusively metallurgical is such that the metals industry cannot afford "to sell chemical engineering short".

The earliest application of fluidisation to ore treatment mentioned in print is, interestingly enough, one of the forgotten premature patents, namely that of Robinson,[2] who, in 1879, patented a fluidised method of roasting auriferous ore, in which the material was to "play like the waters of a fountain".

When the success of fluidised petroleum cracking had become public, the application of the established technique to other fields of technology became commercially possible, a likelihood already foreshadowed in some of the oil industry patents. By 1950 a number of organisations were working out methods of using fluidisation in the treatment of metalliferous ores.

Among the first of the new applications was that recorded for the roasting of pyritic gold ores containing arsenic.[3] These normally carry about 20-30% of sulphur. For usual roasting of ores with less than 30% sulphur content it has been found necessary to use extra fuel in order to maintain the mass at roasting temperature. With a fluidised reactor it was found possible to roast ore under self-maintaining temperature conditions provided that as little as 12% sulphur was present in the ore feed, even including 12-15% of moisture. With low arsenic feed the usual roast temperature is 600-700°C. With 6-8% arsenic, or more than 2% antimony, it is desirable to use two stages of roasting, the first stage being operated at about 500°C with a deficiency of oxygen, and the second stage being worked at 700°C with excess air. The calcined product is suitable for cyanidation. Some data on the operation of such a plant at the Cauchenour-Willans mine have been given.

Roasting of Pyrites and Sulphides

In *British Chemical Engineering* (October, 1956, p. 324) there has been described the fluidised roasting of pyrites for the preparation of sulphur dioxide for the manufacture of sulphuric acid. In this case the purpose of the roast was primarily to obtain a sulphur gas; the disposal of the pyrites cinder for metallurgical purposes was only an endeavour to recover credits for the process. Nevertheless, a fluidised roaster was installed at an American steelworks in 1953 for the dual purpose of providing sulphur dioxide for acid manufacture and also cinder for the ironworks.

The greatest industrial exploitation of fluidisation in the metallurgical field specifically with a view to preparing a

sulphide for smelting has been in the zinc enterprises. This operation needs a roasting temperature of 900-1000°C to decompose zinc sulphate and demands considerable regularity of temperature.

Many of the American zinc firms have carried out experiments or put units into commission. At an early stage the American Zinc Co. had had pilot-plant scale tests made on 4-in. and 10-in. diameter reactors by the Dorr Co. The New Jersey Zinc Co. developed its own design of reactor with a bed the diameter of which decreased downwards in steps, thereby providing a facility for handling a range of particle sizes in the feed material. In the same development this firm showed the feasibility of pelletising the zinc sulphide, depending upon its origin, with water or a binder such as sulphite lye, bentonite, zinc sulphate or sodium sulphate. The St. Joseph Lead Co. developed a two-stage process in which the zinc concentrates are first treated to volatilise the impurities and then the calcination is completed in a fluidised bed. Operating data on the performance of a zinc calcination plant put up at Arvida by the Aluminium Co. of Canada have been given by Anderson and Bolduc.[5]

Roasting to Sulphates

Instead of roasting sulphides at such a high temperature as to decompose any sulphates formed, it is possible, with suitable ores, to operate at a temperature which will favour the formation of sulphates with a view to removing such sulphates subsequently by leaching. Metals which respond favourably to such treatment are copper and cobalt.

In the fluidised sulphating roast of copper sulphides there is a tendency for the bed to become sticky if too much sulphate is formed. It is therefore convenient to roast the lower grades of ore in this way, at 24-28% copper, rather than the richer 35-40% material.

If the raw material is a copper-bearing iron pyrites, such as Rio Tinto, it should not be roasted at greater than 850°C in order to permit satisfactory leaching of the copper.

The application of the sulphating roast in a fluidised bed for obtaining cobalt has been aided by the studies carried out at the Battelle Memorial Institute. A large installation has been under construction for Kilombe Mines Ltd. in Uganda, where there are proved deposits of several million tons of ore containing 1.43-2.25% copper and 0.135-0.171% cobalt. It is planned to roast a concentrate in fluidised units at the rate of 650 tons per day, and then to leach the copper and cobalt.

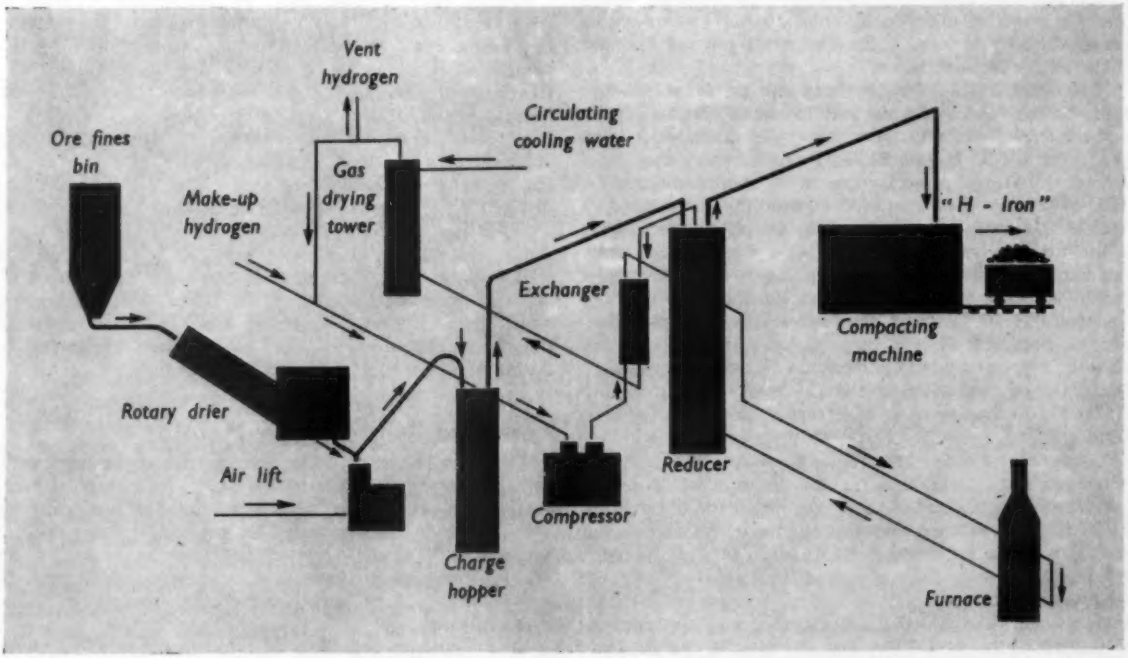
Thermal Conversion of Physical Structure

In some metallurgical processes it is useful to convert material from one crystal structure to another, either to aid separation or to change the quality of the product. A well-known case of quality changing is the thermal conversion of titanium dioxide from the anatase to the rutile structure, thereby obtaining a pigment which avoids susceptibility to "chalking" of paints used outdoors.

Fluidisation has been proposed for a number of such requirements. An early development was the investigation by the Dorr Co. and the United States Steel Co. of fluidised magnetising roasting of iron ores. This work was subsequently extended to the study of the magnetising roasting of the Lorraine ores of France, under a contract placed by IRSID (the research organisation of the French iron and steel industry). It was reported in 1952 that, although it was thus possible to carry out a two-stage fluidised roast (including a stage reducing the iron oxide to the magnetic form, prior to magnetic separation of the oxide from the gangue), the system would only be economic for naturally occurring fine material and would not pay for special crushing.

Aluminium Laboratories Ltd. of Montreal have proposed an electrically heated fluidised roaster for the conversion of gibbsite to gamma alumina or for the conversion of normal alumina to gamma alumina.

Characteristic of the period of the rise of the "new metals" has been the spread of what is called "chlorine metallurgy". The reasons for this are the highly reactive nature of chlorine and other halogens, permitting the treatment of relatively refractory ores, and the fact that chlorides of metals are in a number of cases sufficiently volatile to allow distillation and even fractionation.



Flow diagram for iron oxide reduction plant (after "The Iron Age").

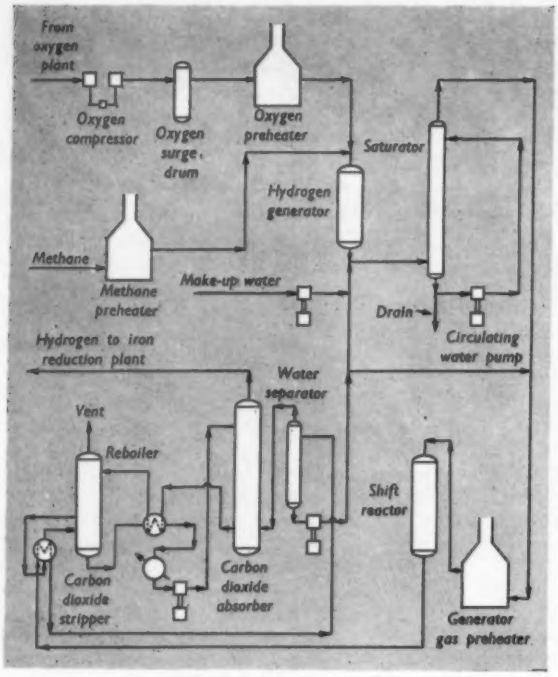


Diagram of the hydrogen generating plant based upon reaction of methane with oxygen.

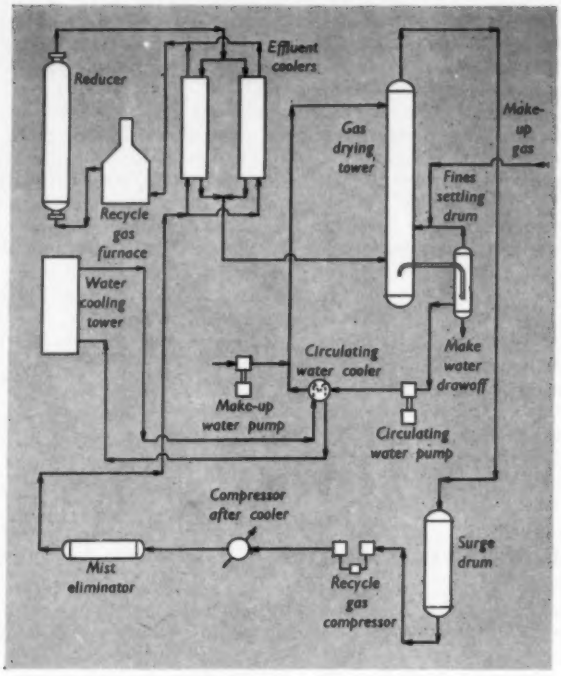


Diagram of the iron oxide reducing plant. (Diagrams: Hydrocarbon Research Inc.)

One of the first proposals for the fluidised halogenation of a metal arose from the petroleum industry, which in the past had used substantial quantities of metal chlorides, in particular aluminium chloride, for catalytic processing. The Esso Development Co. disclosed a method of manufacturing aluminium chloride in which alumina is heated with powdered coke fluidised by a stream of chlorine to form the required compound.[6] This method is a straightforward fluidised adaptation of the previous method, which employed briquettes of alumina and coke in a shaft kiln. A number of other metal chlorides are susceptible to manufacture by the same technique, being previously made by the briquette method.

Titanium tetrachloride has been the principal product from the new fluidised chlorination route. Details of the procedure used at the du Pont factory at Edge Moor have been given by R. L. Powell.[7] and experimental data on a Bureau of Mines project have also been recorded.[8] A fluidised process is in operation at the Billingham plant of Titanium Intermediates Ltd. which supplies tetrachloride to the titanium metal plant of I.C.I., which is currently stated to produce 1500 tons of metal per year, needing at least 6000 tons per year of tetrachloride. The du Pont organisation is now using tetrachloride for the manufacture of titanium dioxide by high-temperature oxidation with air, a process which permits the recovery of chlorine. The scale of operation at the du Pont works is about 15,000-20,000 tons per year of tetrachloride by the fluidised route.

A number of other fluidised processes have become associated with the manufacture of titanium tetrachloride. For example, a method has been proposed for the upgrading of ilmenite sands by contacting them with chlorine at 1000°C with the preferential chlorination of iron, whereby the ferric chloride thus produced is carried off by the exhaust gases, and titanium dioxide is withdrawn from the fluidised bed. A principal trouble in the chlorine treatment of the titanium ores, rutile and ilmenite, is the parasitic production of ferric chloride, and the du Pont organisation has described methods for the recovery of chlorine from ferric chloride.[9] Thus ferric chloride vapour, mixed with air or oxygen, is fed through a bed of fluidised particles of ferric oxide at 600-800°C, which promotes the formation of chlorine and helps to keep the reactor walls clean.

Instead of recovering the oxide by treatment of the chloride with oxygen, details have been given of some processes in which the oxide of the metal is recovered by treatment with steam.

Besides carbon, other reducing agents may be used to help chlorination, and other halogens (particularly fluorine) suggest themselves for the production of metal compounds used in the nuclear energy programme. The treatment of metal sulphides directly with chlorine has also been explored. Under suitable conditions it is possible to form metal chlorides by treatment of ores with hydrochloric acid gas, which, in effect, consists of a joint reducing agent and halogenating agent. The chloride may be distilled or left in the solid to be leached out with water. This, in part, provides a fluidised equivalent of the traditional chloridising roast with salt. Some patents on the hydrochloric acid treatment of iron ore to form ferric chloride have been granted to the United Steel Companies Ltd.[10] The Imperial Smelting Co. Ltd. manufactures aluminium fluoride by the fluidised-bed treatment of hydrated alumina with hydrofluoric acid.

Fluidised Reduction to Metal

The possibilities of being able to reduce ore fines without preliminary agglomeration have been explored for many years. H. Brassert[11] proposed the fluidised reduction of iron ores by hydrogen and his suggestion was published by the Bureau of Mines in 1947. As in many of the fluidised process proposals, this merely represented the continuation of hydrogen reduction attempts by other means.

Direct gaseous reduction of lump iron ore and sintered fine ore has been pursued by a number of Swedish workers

to the extent that at least one of the methods (Wiberg) is used for small-scale production of sponge iron to supply the electric steel industry. In this process,[12] which has been very carefully worked out with considerable attention to the technical and economic aspects of the problem, high-grade Swedish iron ore, either in small lumps or as sinter, is reduced at about 1000°C in a shaft furnace with a reducing gas mixture containing about 75% carbon monoxide and 25% hydrogen. Since water and carbon dioxide are formed in the reducing process, a large proportion of the gas is recirculated through an electrically heated furnace containing coke to bring about the removal of the reaction products and the regeneration of the gas so that it may be used again.

Experimental work on the fluidised reduction of iron with hydrogen was made available in 1951 by Tenenbaum and Squarcy[13] of the Inland Steel Co. The results were not particularly encouraging, showing that in order to obtain high rates of reduction it was necessary to operate at temperatures of the order of 850°C. Unfortunately, at this temperature the reduced iron tends to stick together. Another disadvantage of this route was that it was not possible to obtain iron ores pure enough to permit the reduced iron to be used directly in any metal-forming operation. The product from reduction would have to be used as a substitute for scrap or for pig iron in the steel furnace, depending upon its purity.

The reduction of nickel oxide with hydrogen in a fluidised bed has been studied.

With metal compounds already purified, or with metal compounds yielding a volatile metal, it was possible to envisage the preparation of a pure metal directly. Thus, in the case of zinc, which may be distilled, the opportunity presented itself for a fluidised method. In this field several patents have been granted to the American Metal Co. for the reduction of zinc oxide at temperatures above the boiling point of zinc[14] and Lacey and Sheerar presented a paper to the American Chemical Society in 1950 dealing with the reduction of zinc oxide with natural gas using a fluidisation technique.

The reduction of ferric chloride already distilled from iron ore has been patented by the United Steel Companies Ltd.[15] and the hydrogen reduction of distilled ferrous chloride has been suggested, although the latter was not in connection with a fluidised process.

The most exotic suggestion for the fluidised reduction of a metal compound to the metal in a fluidised bed has been the patent[16] sought by I.C.I. for the process involving the fluidisation of a bed of particles of sodium chloride coated with metallic sodium by passing a stream of titanium tetrachloride vapour mixed with argon, the aim of the process being the formation of metallic titanium.

Other possible reducing agents are carbon monoxide, or mixtures of it with hydrogen, or a solid, such as carbon, suitably fluidised in contact with the oxide by a reducing or a non-reactive gas.

H-Iron

In spite of the large number of methods already tried for the processing of iron ore fines, and the difficulties experienced with the fluidised reduction with hydrogen at atmospheric pressure, work has continued in a number of directions.

The principal departure in the fluidised process has been the application of the hydrogen under pressure. This has brought about two consequences: first, the high operating pressure has permitted the obtaining of high rates of reduction; and, second, these high rates of reduction may be obtained at temperatures low enough to prevent any danger of agglomeration of the reduced product in the reactor. The process using pressure hydrogen has been claimed by Hydrocarbon Research Inc.[17] The essential features of the process include the passing of high-purity hydrogen upward through a bed of fine iron oxide at a rate sufficient to keep it fluidised, and maintaining the bed at a temperature of 370-540°C with a hydrogen pressure between 200 and 600 psi. The purity of the hydrogen has to be such that the average molecular weight does not exceed 7.5, and the water vapour content must not exceed 0.5% by volume at 370°C, or 3% at 540°C.

Development work on the process has been carried out by Hydrocarbon Research Inc. in conjunction with Bethlehem Steel Co. and a large pilot plant has been constructed and operated at Trenton, N.J. Fundamental to the economic prospects of the development has been the availability of the partial oxidation process under pressure, devised by Texaco and Hydrocarbon Research, for the production of hydrogen from fuel by reaction with oxygen.[18] Preliminary economic analyses made by Hydrocarbon Research suggest that it may be cheaper to make hydrogen for reduction than the coke used at present.

The Trenton Pilot Plant

The pilot plant reactor at Trenton is 34 in. internal diameter and 30 ft. high. Under typical conditions the reactor is run at 480°C under a pressure of 400 psi. Ore fines in the size range −20 to 325 mesh are fed to a rotary ore dryer and there dried and raised in temperature to suit the conditions in the reactor. The hot ore is transferred by air lift to a vertical charge hopper, which it filled and isolated. The charge hopper is top-pressured with hydrogen to a sufficient degree to push the ore into the reduction vessel under "dense phase" conditions. Water vapour formed in the reduction process is removed from the gas stream by cooling the outgoing gas to 30°C before recirculating.

The reduced powder is discharged hot through a set of revolving rolls which compress the particles to a rather dense plate. This is essential in order to prevent rapid oxidation of the fine reduced material. Even after the compression there is considerable tendency for the iron to oxidise or rust, but further passivation is under way. To provide easy handling of the compressed iron, the plate product is broken into chips by suitable breaking rolls.

This process has been operated with a number of the iron ores which are readily available in the United States and other foreign sources. It is stated[19] that too many inerts in the ore make the reduced product unsuitable for use in the open hearth furnace. The suggestion from experimental heats is that H-iron made from ore fines containing only 3-4% of inerts is satisfactory for providing part of the steel-making charge.

Meanwhile, other processes for handling iron ore fines enter the technical journals and are eagerly discussed, processes using old techniques with a twist, such as the suggestion of W. K. Lewis that fluidised ore and fuel should be blown into the base of the conventional blast furnace, or new processes with a twist such as the use of the cyclone furnace fed with fuel and ore fines.

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Plastics in the Construction of Chemical Plant — Part 2

The tank illustrated is fabricated from a polyester-fibre glass laminate and is satisfactory for concentrated hydrochloric acid solutions (Microplas Ltd.).

by V. E. YARSLEY, D.Sc. (Zürich), M.Sc. (Birmingham), F.R.I.C., M.I.Chem.E., F.R.I.

MOULDED units found natural application in chemical plants for standard parts which could be used in the large numbers necessary to justify the inevitable high mould costs. They have in this connection supplied the electrical gear and fittings, and the covers and protective units, for which the corrosion-prone metals had formerly functioned less adequately. One of the early substitutions of moulded plastics for metals was the historical Topham spinning "pot" used in the production of viscose rayon, and later this was extended to the bobbins and shuttle parts which go into the weaving of these and similar fibres.

Moulded units have been used mainly for the smaller parts of key importance where high duty performance was called for. In this connection special mention must be made of nylon, in the development of which its use as a bearing possibly figured before its use as a fibre. The use of plastics as specialist bearing materials and gears has indeed covered the application of many plastics.

Mouldings of key importance in chemical plants have also been prepared in what is possibly the most difficult of all plastics to form in this way, polytetrafluorethylene (PTFE), known in this country under the trade name "Fluon". By reason of the remarkable physical as well as chemical nature of this material, such mouldings have to be cold formed, and subsequently "consolidated" by sintering. PTFE is also used in the production of gland packings for chemical plant, and these, in spite of their high cost (at one time as much as £20 per pound of finished product), have found an extended market on the basis of performance merit. In most instances they outlast conventional materials on a cost basis, and where this is not the case any adverse cost is more than compensated by the reduced "dead" time in plant operation. An interesting technique developed some time ago in this country by Ediswan Ltd., made possible the bonding of "Fluon" units to metal by first metallising the plastic surface, and then soldering this surface to the metal plant after tinning it in the normal manner.

Melts, Syrups, Solutions and Emulsions

Plastics materials in physical forms which are readily fluid, with or without the application of elevated temperature, correlate one of the fields of considerable application potential in chemical engineering. In this way it is possible to effect that intimate combination of plastics with the less costly load bearing materials. Where, as is so frequently the case, the ideal material for plant construction is a metal, all that is needed is a thin protecting layer of a chemically resistant plastic, this can usually be easily and economically applied as a melt, solution or emulsion, depending on the chemical nature of the plant in question.

The application of epoxide resins has recently found considerable use in this way, not only as protective coatings, but also as bonding agents for a wide range of metals. Some plastics such as the halogenated hydrocarbon polymers (which owe their effectiveness to their chemical resistance, are soluble with difficulty or indeed completely insoluble in solvents which could safely be applied to metals) and long defied successful application as bonding agents. Success came eventually when it became possible to prepare them in the form of stable emulsions. In this connection considerable progress has recently been made in the application of the fluoro and chloro-fluoro hydrocarbon polymers, and today emulsions of PTFE, for example, are applied as protective coatings to a wide range of intricate chemical plant units.

The secret of success in work of this nature is the complete cleanliness of the surface of the metal to be coated, and shot-blasting as well as solvent treatment of the surface is a pre-requisite. Once the emulsion has been uniformly applied, the whole plant unit has to be "stoved" to sinter the polymer and give a perfectly continuous and completely adherent protective plastics layer. Experience is still being bought the hard way in this field, but such is the advantage to be gained that initial failures have fortunately not been an undue deterrent. The application of

these emulsions in Britain has hitherto been restricted by their high cost, but recent price cuts of more than 50% because of increased production, together with their more readily availability from home-produced sources, has given a great impetus to their use.

Plastics pastes applied to fabrics have also found extended application in chemical plants in recent years. This development was actually first sponsored by another industry and adopted extensively for use in coal-mine conveyor belts, for many years a rubber monopoly. The chemical industry has many uses for flexible conveyors which are not only chemically resistant, but also tough and resistant to friction. The same properties are called for in flexible membranes for a variety of uses notably in fluid control valves.

Plastics Prevent Sticking

An application of considerable significance in many chemical operations, in which plastics function ancillary to the plant, is their use to prevent sticking. In many chemical operations much plant time, and indeed actual material, is lost owing to the necessity of cleaning the unit between each production batch. It is one of the added attractions of plant coated with PTFE that very few tacky substances will adhere long to the surface, so that the use of these coatings greatly reduces cleaning time and boosts productivity. Much the same results can be obtained by the use of special silicon plastics, which when sprayed or wiped on to the surfaces of plant facilitates the rapid removal of the most tacky of products.

An interesting application of plastics melts and syrups, albeit one not exclusively related to the sphere of chemical engineering, is their use in the production of moulding tools. Forming tools cast from ethyl cellulose compositions or in the more recently developed polyesters and epoxides, are rapidly replacing metals in this particular application. The increased speed of production and lower over-all costs of such moulds accounts for their ready acceptance which, during the past few years, has been little short of spectacular. America, in particular, is a case in point.

Various plastics, notably those of the urea formaldehyde, phenol formaldehyde, polyvinyl chloride, polyurethane and polystyrene families, are used in the production of what are now widely known and used as sponge or expanded plastics. These are of two main physical types, the open-cell type produced by whipping up or emulsifying the plastics composition so that as much air as can be contained is included in the mass, and the closed-cell type in which the small cavities are formed by a gas generated *in situ* usually by means of a blowing agent. These materials are excellent thermal insulators, and in consequence of their superior chemical resistance, they are now widely applied in the lagging of chemical plant. They have the advantage that they can, in many instances, be "cast" to shape, so they are particularly useful in the lagging of intricate plant.

Expanded plastics, particularly those of the polyurethane type, combine lightness with a remarkable degree of strength and they can therefore be used in fixing plant units in position. This was a technique developed in aircraft construction, but one which is now being applied to chemical plant. The ability of these plastics to bond securely to metals makes it possible to form a perfectly bonded "sandwich" of metal and expanded plastic. A novel application of expanded plastics in the chemical industry is the use of "microballoons" in the sealing of volatile solvent tanks. Small beads of "p.f." are expanded to several times their original volume, so that they are in effect small hollow spheres. These float on the surface of a volatile solvent in a storage tank providing a perfectly mobile yet reasonably vapour-tight surface, which considerably reduces evaporation.

This, very briefly, is the story of the possibilities of plastics in chemical engineering. In many physical forms and chemical types plastics have much to offer, and as time passes it becomes even more evident that what has been accomplished may be as nothing compared with what is yet to come. Most certainly the possibilities of these remarkable materials are limited only by the imagination of the users. It is perhaps logical that the wheel should turn full cycle, and that materials which started as single chemicals should aid the progress of further chemical formation and transformation.

A table listing the plastics materials available in Britain, and indicating their properties, appears on pp. 430-33. It is not intended to be comprehensive, either as regards types of material available or as to completeness of all available physical forms, and it has not been possible to ensure that all of the U.K. registered names are quoted in it. The prices listed refer, unless otherwise stated, to the raw material (e.g., moulding compound) and not to fabricated articles. The physical properties stated are intended to be representative of average materials in each category (a considerable range usually being offered within each group) and those categories are indicated in which special grades with markedly different properties are obtainable. Nevertheless, there may be other materials within each grade which have been designed by producers to meet special needs and that are consequently outside the range of, or are qualitatively different from, the descriptions given. This point deserves particular emphasis, since it would be unwise to make any definite statement regarding the optimum properties obtainable from a particular class of material, as the plastics industry is constantly endeavouring to improve the properties of all types.

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The author wishes to express his appreciation of the assistance of **L. W. Turner, Dr. W. G. Barb, W. Flavell** *and* **A. B. Cobb** *in the preparation of the table listing the plastics materials available in Britain.*

Designation of Plastics Materials	Classification Thermoplastic or Thermosetting	Physical Form in which Commercially Available	Some Current U.K. Trade-marks. (If no U.K. supply, as imported)	Cost Order at October 1956	Density (gm./c.c.)	Maximum Use Temperature
PHENOLICS Moulding Powders	TS	Moulding powder Mouldings Extruded sections	Bakelite Elo Mouldrite Nestorite Rockite Sternite	1/6-3/6 per lb.	1.3-1.5	About 120°C Special grades up to 230°C
RESINS Laminating	TS	Liquid Solution Solid	Bakelite Catanam Elo Epok Nestor Mouldrite Wresinex	16/0-20/0 per gal.	1.0-1.2	—
Surface Coating	TS	Solid Solution	Bakelite Epok Nestor Superbeckacite	17/0-45/0 per gal.	0.9-1.0	—
ADHESIVES AND CEMENTS	TS	Viscous liquid Solution	Aerodux Bakelite Cascophen Catament Mouldrite Cellobond Lauxite Nestor	9d.-4/0 per lb.	1.1-1.3	120°C
LAMINATES Industrial	TS	Sheet Rod Tube Angle	Ashlam Formapex Holoplast Trefoil Tufnol	2/6-15/0 per lb.	1.3-1.4	80°C
Decorative		Sheet	Formica Klingdecor Warerite	4/0-5/9 per sq. ft.	1.3-1.4	—
AMINOPLASTICS Urea Moulding Powders	TS	Moulding powder Mouldings	Beetle Mouldrite Rockite Scarab	1/2-1/10 per lb.	1.4-1.8	110°C
Melamine Moulding Powders	TS	Moulding powder Mouldings	Melmex	2/9-3/0 per lb.	1.4-1.8	150°C
RESINS Surface Coating		Solution	Beckamine Beetle Epok Superbeckamine Wresilac	15/0-20/0 per lb.	0.8-0.9	100°C
ADHESIVES		Viscous liquid Powder	Aerolite Beetle Casco-resin Cellobond Mouldrite Vitrite	7d.-9d. per lb.	1.30-1.32	—
CELLULOID	TP	Film Sheet Rod Tube Lacquer	Xylonite	6/0 per lb.	1.35-1.60	70°C
CELLULOSE ACETATE	TP	Film Sheet Rod Tube Lacquer Moulding granules	Bexoid Celastoid Erinoid Utilex	7/6 per lb. for sheet 2/0-3/0 for moulding powder	1.30-1.50	80°C
CELLULOSE ACETATE BUTYRATE	TP	Film Sheet Rod Tube Lacquer Moulding granules	Tenite II (U.S.) Cellidor B (German)	5/1-5/10 per lb.	1.14-1.22	90°C
ETHYL CELLULOSE	TP	Film Sheet Melt compound Lacquer Moulding powder	Ethocell (U.S.) ...	6/0 per lb.	1.10-1.25	100°C
POLYTHENE Soft (low density)	TP	Fine powder Layflat film Sheet Tube Moulding granules	Alkathene Telcothene	2/11 per lb. 6/5 per lb.	0.92	90°C
Hard (high density)	TP	Granules Fine powder	Alkathene HD Marlex 50 (U.S.) Hostalen (German)	— 4/0 per lb. 4/1-4/4 per lb.	0.93-0.96	100 -110°C

Chemical Properties			Mechanical Properties	Electrical Properties	Some Applications in Chemical Engineering and Chemical Industry
Resistance to Acids	Resistance to Alkalis	Resistance to Solvents			
Good, except with strong oxidising agents	Good except for strongest alkalis	Generally good	Hard, rigid materials of low shock resistance, except in reinforced grades	Useful for low-frequency applications Resistance and electric strength quite good Power factor fairly high	Moulded electrical fittings
Good, except with strong acids	Fair with weaker alkalis	Generally good	—	—	See Laminates
Good, except with strong acids	Fair with weaker alkalis	Generally good	—	—	Chemically - resistant coatings and insulating varnishes
Good, except with strong acids	Fair with weaker alkalis	Generally good	—	—	Acid-resistant adhesives and cements
Good, except with strong acids	Fair with weaker alkalis	Generally good	Reinforced rigid materials of high strength and shock resistance	Resistance and electric strength quite good Power factor fairly high Useful for low frequency applications	Acid-resistant fittings Bearing surfaces Electrical bushings
Good, except with strong acids	Fair with weaker alkalis	Generally good	Laminates as above, but with surface of resistant amino-plastic	—	Decorative surfacing
Fair to good	Fair to good	Generally good	Hard, rigid materials of moderate shock resistance	Resistance and electric strength quite good Power factor fairly high	Moulded electrical fittings
Fair to good	Fair to good	Generally good	Hard, rigid materials of moderate shock resistance	Resistance and electric strength fairly good Power factor fairly high Good tracking qualities	Moulded electrical fittings
Fair	Fair	Generally good	—	—	Chemically - resistant coatings and decorative finishes
Fair	Fair	Good	—	—	Constructional adhesives for woodwork Plywood manufacture
Good with weak acids	Poor	Poor	Tough, rigid material	Fairly good, but little used because of inflammability risk	Hand-rail coverings Name and instruction plates Limited use in chemical industry
Fair	Poor	Poor	Moderately tough, rigid material	Moisture absorption in most grades is high, limiting electrical applications	General mouldings Limited application to chemical industry
Fair	Poor	Poor	Tough material of fair rigidity	Moderately good	Tough mouldings for outdoor applications Signs, covers, pipes
Fair	Fair	Poor	Tough material of varying rigidity	Properties quite useful at lower frequencies	Special mouldings where toughness is required Dipping compound for covering Press-tool blocks
Good	Good	Good	Very tough material Flexibility decreases with increasing density	Very low loss, even at high frequencies Excellent insulator	Metal coatings, pipes, small tanks, buckets and other containers, packaging for chemicals, bag and drum linings, funnels, cable covering

Designation of Plastics Materials	Classification Thermoplastic or Thermosetting	Physical Form in which Commercially Available	Some Current U.K. Trade-marks. (If no U.K. supply, as imported)	Cost Order at October 1956	Density (gm./c.c.)	Maximum Use Temperature
POLYVINYL CHLORIDE	TP	Film Sheet Rod Tube Moulding granules Powder Paste Foam	Welvic Geon Vybak	2/0 per lb. (powder) 2/5 per lb. (moulding granules or paste) 4/0 per lb. (sheet)	1.3-1.4	70°C
VINYL COPOLYMERS	TP	Powder Sheet Film Rod Tube Filament	Vinylite Cobex Vybak Geon	2/0-5/0 per lb.	1.3	60°C
POLYVINYLIDENE CHLORIDE (Copolymers containing predominantly vinylidene chloride)	TP	Filament Film Tube Strip Emulsion	Saran (U.S.)	7/6-10/6 per lb.	1.7	70°C
POLYVINYL ACETATE	TP	Granules Solution Emulsion	Emultex Vinamul Polimul Gelva	2/6-5/0 per lb.	1.19	50°C
POLYVINYL ALCOHOL	TP	Powder Film Tubing	Solvar Mowiol (German) Resistoflex (U.S.) Pevalon Alcotex Polyviol	6/0-7/0 per lb.	1.2-1.3	100°C unplasticised
POLYSTYRENE	TP	Sheet Rod Tube Moulding Film Monofilament Expanded material	Bextrene Distrene Styron Erinoid Kleestron Lustrex Styrafoil Styrathread Polyzote Spandoplast	2/7-3/0 per lb. for moulding powder	1.05	90°C
STYRENE-BUTADIENE COPOLYMERS	TP	Crumb Sheet	Butakon S Tred Pliolite	2/6-3/3 per lb.	1.05	50°C
POLYMETHYL METHACRYLATE	TP	Sheet Tube Moulding granules	Perspex Diakon	5/0-5/6 per lb.	1.19	90°
METHYL METHACRYLATE/BUTADIENE COPOLYMERS	TP	Crumb Emulsion	Butakon M		≃ 1.15	—
POLYTETRAFLUOROETHYLENE	TP	Powder Dispersion Tape Rod Tube	Fluon Teflon (U.S.)	70/0 per lb.	2.2	250°C
POLYTRIFLUOROMONOCHOROETHYLENE	TP	Moulding granules Powder Dispersion	Kel F (U.S.) Hostaflon (German)	70/0 per lb.	2.12	200°C
POLYAMIDES	TP	Moulding granules Rod Filament Woven cloth	Maranyl Akulon (Dutch) Grilon (Swiss) Rilsan (French) Durethan BK (German)	7/9-18/6 per lb.	1.14	140°C
POLYURETHANE	TP	Granules Filament	Durethan U (German)	14/9-17/6 per lb.	1.21	140°C
POLYESTERS Resins	TS	Liquid	Marco Crystic Filabond Cellobond	4/0-4/6 per lb.	1.10	120°C
Fibre-glass Laminates	TS	Tube Plain and corrugated sheeting	Cascalite Sarolite	Dependant on gauge, etc.	≃ 2.0	120°C
EPOXIDES	TS	Viscous liquid Solid	Epikote Epophen Araldite	5/6-14/6 per lb.	1.1	160°C
SILICON PLASTICS Silicones	TP or TS	Liquid	—	10/0-25/0 per lb.	1.1-2.5	250°C
SILICONE RUBBERS	TS	Liquid Gum Solid	Silastomer	20/0-40/0 per lb.	1.1-2.5	250°C

Chemical Properties			Mechanical Properties	Electrical Properties	Some Applications in Chemical Engineering and Chemical Industry
Resistance to Acids	Resistance to Alkalis	Resistance to Solvents			
Good	Good	Good	Tough material of wide range of flexibility	Good insulator Moderate loss factor Useful at lower frequencies	Metal coverings Protective clothing, tubes and pipes Belts, cable covering, battery separator
Good	Good	Variable	Tough material of wide range of flexibility	Slightly less good than polyvinyl chloride	Chemical plant equipment such as ducts, pipe-lines, hoods, screens, etc. Metal coatings
Good	Good	Good	Very tough and abrasion-resistant Somewhat brittle at low temperatures	Fairly high loss factor	Filter cloths Industrial brushes Pipe-lines for acids and alkalis Packaging foils Coatings and impregnations
Fair	Poor	Poor	Tough and flexible when plasticised	Poor	Paints and varnishes Adhesives for wood, paper, cloth, etc. Textile impregnation
Water-sensitive	Water-sensitive	Good	Tough and flexible when plasticised	Poor	Solvent-resistant tubes and gaskets Sizes Impregnants Finishes
Good	Good	Variable but generally poor	Somewhat brittle except in "high impact" grades	Excellent insulator at all frequencies	Electrical insulation of high frequencies Moulded pieces In foam form for electrical, thermal and sound insulation
Good	Good	Variable	Tough and leathery good abrasion resistance	Very good	Floor tiling Unbreakable containers Shoe soling
Fair	Fair	Variable	Transparent material of moderate toughness	Quite good at lower frequencies	Special linings and covers Windows and roof lights
Fair	Fair	Moderate	Tough and leathery	—	Surfaces, finishes
Good	Good	Good	Fairly tough	Excellent properties over a wide frequency range	Low friction and low adhesion applications Chemical and heat-resisting applications such as coating, sleevings, tapes, diaphragms
Good	Good	Good	Tough	Excellent properties over a wide frequency range	Chemical and heat-resisting parts Electrical applications
Good	Good	Good	Strong and rigid with good abrasion resistance	Moisture absorption is high, so electrical applications limited	Industrial brushes Bearings Gears Bobbins Filter cloths
Good	Good	Good	Strong and rigid	Resistance and electric strength quite good, but loss factor fairly high	Brushes Mouldings
Quite good	Quite Good	Quite Good	Rigid to moderately flexible	Good insulation and fairly low loss, but sensitive to water absorption	Potting electrical components Castings
Quite good	Quite good	Quite good	High shock-resistance and great strength	—	Tanks, pipes and ductings, translucent roofing, etc. strong structures generally
Good except for oxidising agents	Good	Very good	Somewhat brittle can be modified to give flexible products Can be reinforced to give high strength and shock-resistance	High resistance and electric strength Moderate loss factor	Adhesives to metal, glass, plastics and wood Coatings and impregnants Tools and jigs Surface coatings Potting electrical components
Good	Good	Good	Not very good, but temperature insensitive	Generally good	Heat-resistant laminates Heat-resistant varnishes and paints
Good	Good	Good	Not very good, but temperature insensitive	Generally good	Heat-resistant materials, such as: Seals, gaskets, cables, applications where constant moderate mechanical properties are preferred to good properties which may drop rapidly under adverse conditions

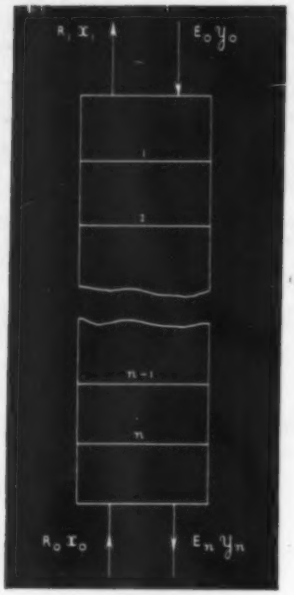

Fig. 1

The Distribution Diagram in Liquid-Liquid Extraction

This article describes a new method of constructing the operating line in an extraction process, and of estimating the number of equilibrium steps required, which overcomes some of the difficulties encountered with earlier methods. Two examples are given to illustrate the procedure

by S. R. M. ELLIS*

ONE general method of using distribution co-ordinates has been proposed by Varteressian and Fenske[2] and discussed by Treybal[5] and Elgin.[1] The solubility data and the overall material balances are first expressed on triangular co-ordinates. The points of intersection of the terminal operating lines are next located, and individual operating lines are transferred to rectangular distribution co-ordinates to give the operating curve. A criticism of this procedure is that inaccuracies occur in transferring operating-line data from one graphical construction to another. This criticism is valid for liquid-liquid extraction with reflux when the number of equilibrium stages is high and the concentration of solute in the extract phase is low.

Here an alternative construction is suggested whereby this transfer of operating-line data from triangular to rectangular co-ordinates is avoided. As in the method of Varteressian and Fenske,[6] a distribution diagram is used on a solvent-included basis.

Graphical Construction

Consider a continuous counter-current extraction unit as is shown in Fig. 1, where:

R_0 and R_1 are the raffinate streams entering and leaving the column;

E_0 and E_n are the extract streams entering and leaving the column;

x_0 and x_1 the terminal solute compositions in the raffinate phase, and

y_0 and y_n the terminal solute compositions in the extract phase.

If the raffinate and extract phases are immiscible, but the solute concentration is relatively high, then:

$$\frac{R_1}{E_0} \simeq \frac{R_0}{E_n}$$

In Fig. 2 the equilibrium data are plotted as mole or weight fraction in the extract phase against mole or weight fraction in the raffinate phase. The terminal compositions, x_1 y_0 and x_0 y_n, are located and the operating lines of slopes

$$\frac{R_1}{E_0} \text{ and } \frac{R_0}{E_n}$$

drawn through these respective compositions. The equations for the terminal operating lines are as follows:

$$y = \frac{R_1}{E_0}(x - x_1) = r_1(x - x_1) \quad \ldots . (1)$$

$$y = \frac{R_0}{E_n}(x - x_0) + y_n = r_2(x - x_0) + y_n \quad \ldots . (2)$$

where $r_1 = \frac{R_1}{E_0}$ and $r_2 = \frac{R_0}{E_n}$

The stagewise construction is commenced from y_0 x_1 by drawing a vertical line to the equilibrium curve at y_1 and then a horizontal line drawn to intersect the appropriate operating line at x_2. This operating line of slope m is located by joining G and H, the distances AG and BH being determined by Equations (3) and (4).

$$AG = \frac{y_1 - y_0}{y_n - y_0} \times AE \quad \ldots . (3)$$

$$BH = \frac{y_1 - y_0}{y_n - y_0} \times BD \quad \ldots . (4)$$

The construction is now continued with a vertical line from x_2 to y_2 on the equilibrium curve, followed by a horizontal line from y_2 to x_3 on the operating line G' H' of slope m' where

$$AG' = \frac{y_2 - y_0}{y_n - y_0} \times AE \quad \ldots . (5)$$

$$BH' = \frac{y_2 - y_0}{y_n - y_0} \times BD \quad \ldots . (6)$$

The procedure is continued up the column until the required number of equilibrium stages is determined. Alternatively, the stagewise construction can be commenced at x_0 y_n, using Equation (7) to locate the intersection of the individual operating lines with AC and DJ.

$$DI = \frac{x_0 - x_n}{x_0 - x_1} DJ \quad \ldots . (7$$

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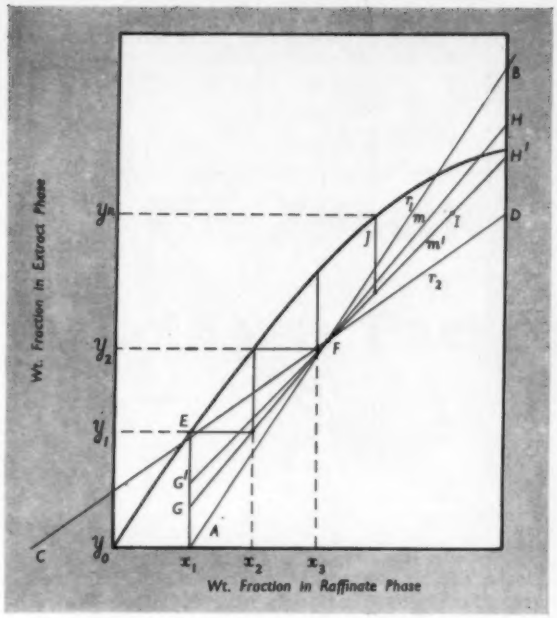

Fig. 2

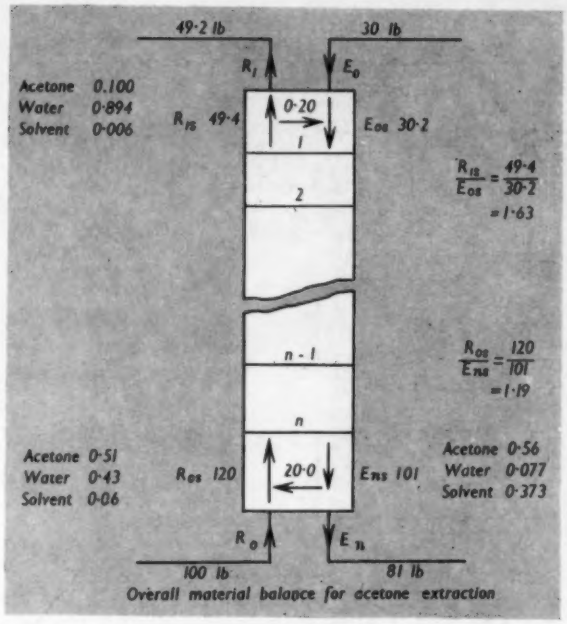

Fig. 3

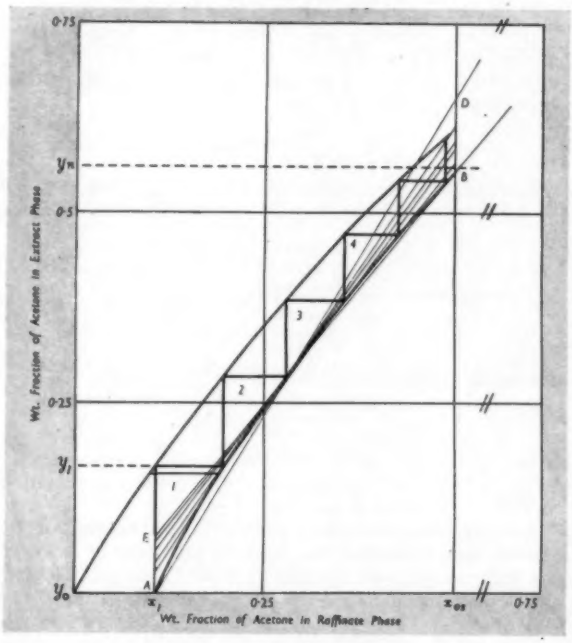

Fig. 4

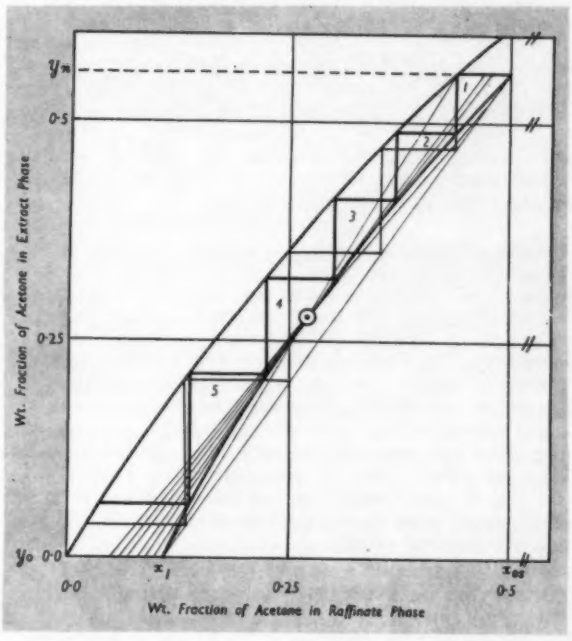

Fig. 5

Jenson[3] has shown mathematically that the above equations hold for a system with immiscible solvent and raffinate phases but with a high solute concentration. The application of the construction to partially immiscible solvents is difficult to prove mathematically, but it can be shown that results obtained by this construction are in close agreement with other methods of calculation for partially immiscible systems.

Example One

The following example is from Treybal,[5] i.e., 100 lb. per hour of a 50.0% acetone and 50.0% water solution is to be reduced to 10.0% acetone with 30 lb./hr of 1,1,2 trichloroethane as solvent in a counter-current multiple-contact operation at 25°C. Determine the number of equilibrium stages.

The overall material balance and terminal compositions are summarised in Fig. 3. The solubility data were first plotted on an equilateral triangle to determine the saturated compositions of the streams entering the column. E_{os} E_{ns}, R_{os} and R_{is} refer to the amounts of saturated extract and raffinate phases.

In Fig. 4 the equilibrium curve is given by plotting the weight fraction in the extract phase, y, against the weight fraction in the raffinate phase, x. Through the composition point y_0 x_1, the operating line of slope

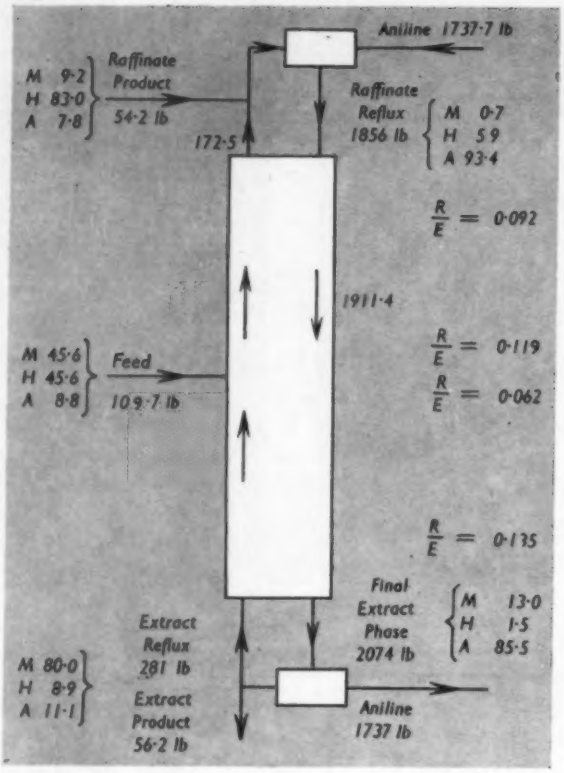

Fig. 6

$$\frac{R_{is}}{E_{os}} = \frac{49.4}{30.2} = 1.63$$

is drawn. Similarly, through $y_n x_{os}$ the operating line of slope

$$\frac{R_{os}}{E_{ns}} = \frac{120}{101} = 1.19$$

is drawn. The vertical distance between the terminal operating lines at x_1 and x_{os} is given by AE and BD.

Commencing the stagewise construction from y_0 x_1 and using Equation (3) to locate the individual operating lines, the number of equilibrium stages is 5.3. The same result is obtained by starting at x_{os} y_n and using Equation (7), i.e., Fig. 5. These results are the same as those obtained by Treybal[5] using the method of Nash and Hunter[4] on triangular co-ordinates.

Example Two

The following example is from Varteressian and Fenske.[6] It is required to separate 100 lb. of a feed of 50.0% w.w. n-heptane, 50.0% w.w. methylcyclohexane using pure aniline as a solvent at 25°C. Aniline is partially miscible with each hydrocarbon and is selective for methylcyclohexane. An extract containing 90.0% w.w. methylcyclohexane and a raffinate containing 90.0% w.w. n-heptane are to be produced. The column is to employ extract and raffinate reflux. For simplicity, the feed, extract and raffinate products are considered to be saturated with solvent.

The actual compositions and quantities flowing to and from the column are summarised by the material balance in Fig. 6. The compositions are referenced as M= methylcyclohexane, H=heptane and A=aniline. All streams entering and leaving the column are saturated. The composition of the extract stream entering the feed-

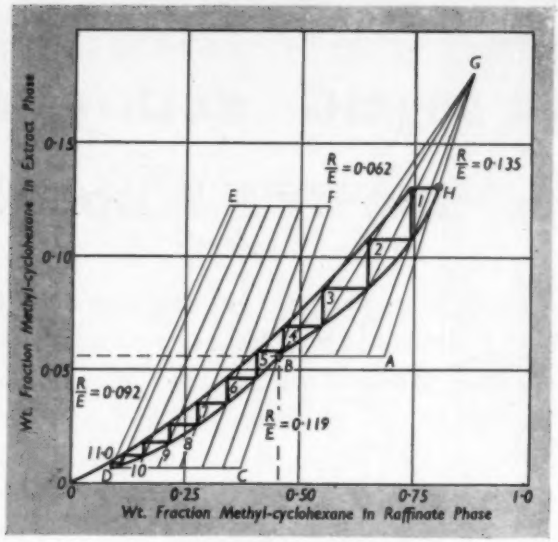

Fig. 7

tray is found by a component material balance over all trays about the feed-tray. This extract stream contains 5.5% methylcyclohexane.

Referring to Figs. 6 and 7, then on Fig. 7 the terminal extract phase and extract reflux compositions of 13.0% and 80.0% methylcyclohexane are located at H and an operating line, AG, of slope

$$\frac{R}{E} = \frac{281}{2074} = 0.135$$

drawn through this composition. At the feed composition B of 5.5% methylcyclohexane the operating line BG of slope

$$\frac{R}{E} = \frac{118.2}{1911.4} = 0.062$$

and the operating line CF of slope

$$\frac{R}{E} = \frac{227.9}{1911.4} = 0.119$$

are drawn. Finally, the operating line DF of slope

$$\frac{R}{E} = \frac{172.5}{1856.0} = 0.092$$

is drawn through D, the raffinate product composition of 9.2% methylcyclohexane and the raffinate reflux composition of 0.7% methylcyclohexane.

Starting from the extract product-reflux composition H, the number of equilibrium stages to the point of entry of the feed composition B is obtained by locating the individual operating line for each stage as shown in Fig. 7. In other words, AB is subdivided in the direct ratio of the percentage stagewise charge in raffinate composition between H and B. Similarly, the number of stages between the feed composition B and the raffinate product-reflux composition D is obtained by dividing DC and EF in the direct ratio of the percentage stagewise change in raffinate composition between B and D. The number of stages required for each part of the extraction process is thus four and seven respectively, giving a total of 11 stages, which is comparable with the 11.3 stages given in the example of Varteressian and Fenske.[6]

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The Effective Wetted Surface in Columns Packed with Raschig Rings

by F. R. WHITT, M.Sc., A.M.I.Chem.E., F.R.I.C

This article emphasises the importance of the effect of liquor rates upon the mass-transfer performances of packed columns, and discusses the quantitative estimations of the variation of effective wetted surfaces with liquor flow in columns with random packed Raschig rings.

SYMBOLS USED

a = effective wetted surface, sq. ft per cu. ft, of packed column;
a_p = surface area of one Raschig ring, in sq. ft;
A_p = correction factor for pressure drop (see Reference 13);
D_T = column diameter, ft;
D_V = molecular diffusivity of gas, sq. ft/hr;
G_M = gas rate, lb. moles/(hr) (sq. ft);
G = gas rate, lb./(hr) (sq. ft);
H = column height, ft;
$H.T.U._{OG}$ = height of an overall gas-phase transfer unit, in ft;
$H.T.U._G$ = height of an individual gas-phase transfer unit, in ft;

$\frac{1}{H.T.U._G} = \frac{k_G a P}{G_M}$ (see Reference 1, p. 132);

$j_D = \frac{k_G p_{BM}}{G_M} \left(\frac{\mu}{\rho D_v}\right)^{\frac{2}{3}}$ (P and p_{BM} taken as 1);

k_G = gas film mass-transfer coefficient, in lb. moles/(hr) (sq. ft) (atm.);
L = liquor rate, lb. (hr) (sq. ft);
p_{BM} = logarithmic mean of partial pressures of non-diffusing gas at phase boundary and in bulk, atm.;
P = Total pressure, atm.;

$Re = \frac{G\sqrt{a_p}}{\mu}$ Reynolds number, modified (See Reference 11);

$Sc = \frac{\mu}{\rho D_v}$ Schmidt number;

ρ = gas density, in lb./cu. ft; and
μ = gas viscosity, in lb./(hr) (ft).

conversion of Liquor Rate Units (see Reference 2, p. 22):
lb./(hr) (sq. ft of empty column cross-section) =
Cu. ft/(hr)/ft of Raschig ring perimeter
× Total Ring Area (in sq. ft/cu. ft) × 62.3.

IT is now well appreciated, as indicated by Sherwood and Pigford[1] (p. 279), that absorption and distillation column packings, such as the commonly used Raschig rings, are not in practice wetted effectively to the full extent of the total rings surface available. Experimental work[1] (p. 281) shows that changes of liquor rate can alter the absorption capacities and presumably the effective wetted surfaces several-fold. Generalised correlations of experimental data giving quantitative relationships between liquor rate, ring size and mass-transfer capacities on effective wetted surfaces in packed columns are given by Sherwood and Pigford[1] (p. 285) and Morris and Jackson[2] (p. 56). The purpose of this article is to supply supplementary correlations in a form convenient for designers and users of columns packed with Raschig rings.

The complete design or "scaling up" from the performance obtained from a particular column involves additional knowledge. The literature[1] (p. 287) and reference 7 (p. 198) indicate that a great deal of quantitative information is available concerning the effect on absorption capacity of Schmidt number values and gas velocities.

Sherwood and Pigford[1] (pp. 226-35) and Zenz[3] give convenient summaries of the literature concerning wetted surfaces in ring-packed columns. Both the total wetted surface data as determined by direct means and the effective wetted surface (for mass-transfer purposes) are discussed.

The first attempt to correlate wetted surface with liquor rate was made by Mayo and others[4] using an ingenious dyeing technique with paper Raschig rings. Grimley[5] used an electrical conductivity method to determine the wetted surface in a column packed with small Raschig rings.

Both the above techniques aimed at a direct determination of the wetted area resulting from the passage of water over Raschig ring-shaped packing. Others[3, 6] have sought to obtain effective wetted areas by more indirect means. Sherwood and Pigford[1] (p. 229) also indicate a calculation method leading to the estimation of the effective wetted surfaces of Raschig rings.

The principle adopted has been to compare mass-transfer results obtained with equipment incorporating a known wetted transfer area with results from equipment similar in other respects except for this factor. Other indirect methods aiming at determining the minimum effective wetting rates have been used.[2, 7] These methods are still, however, associated with mass transfer determinations.

The conclusions reached by Mayo and others[4] for ½ in. Raschig rings are given as a clearly presented plot by Sherwood and Pigford[1] (p. 230). These results and those of

TABLE I

L	Re		$H.T.U_G$	$\frac{1}{H.T.U_G}$	$\frac{k_G a p_{BM}(Sc)^{\frac{2}{3}}}{G_M}$	j_D	a	
500	1820	1.2	0.83	0.59	0.049	12.0		Av. 11.3
	3840	1.7	0.586	0.416	0.0362	11.62		
	6720	2.3	0.416	0.296	0.0285	10.4		

The above is a typical single-point estimation for Fig. 2 curves (Reference 10, p. 289, Humidification of air experimental data). Viscosity of vapour 0.018 centipoises. 2-in. Raschig rings. $\sqrt{ap}$=0.4193 ft. Column 1½ ft diameter. Sc value 0.6, $(Sc)^{\frac{2}{3}}$ 0.71. See Reference 1, p. 20.

L	Re		$H.T.U_G$	$\frac{1}{H.T.U_G}$	$\frac{k_G a p_{BM}(Sc)^{\frac{2}{3}}}{G_M}$	j_D	a	
500	1820	1.8	0.55	0.39	0.049	7.9		Av. 7.85
	3840	2.6	0.375	0.27	0.0136	7.5		
	7680	3.2	0.312	0.22	0.0285	8.15		

The above is a typical single-point estimation for Fig. 2 curves (Reference 10, p. 289, Humidification of air experimental water). Viscosity of vapour 0.018 centipoises. 2-in. Raschig rings. $\sqrt{ap}$=0.419 ft. Column 1½ ft. diameter. Sc value 0.61, $(Sc)^{\frac{2}{3}}$ 0.712. See Reference 1, p. 20.

j_D values at given Re values from Equation (3).

TABLE II

L	Re	G_M	p_{BM}	$\frac{k_G a p_{BM}(Sc)^{\frac{2}{3}}}{G_M}$	j_D	a
290	2260	8.13	0.975	0.29	0.045	6.45
375	5050	18.0	0.988	0.28	0.032	8.7
720	5450	19.4	0.975	0.26	0.0315	8.25
1200	7400	26.5	0.975	0.32	0.0275	11.6

Reference 14, p. 374, Table IV, runs 7, 4, 9 and 10. HCl absorption from methane and air mixture at 760 mm Hg. Viscosity of vapour 0.018 centipoises. 2-in. Raschig rings. $\sqrt{ap}$=0.419 ft. Column 1 ft diameter by 18 ft high. HCl solubility data from Reference 15, p. 752, Fig. 8.

j_D values at given Re values from Equation (3), Sc value taken as 0.6 and $(Sc)^{\frac{2}{3}}$ as 0.71.

Grimley[5] and Zenz,[3] have been changed in form where necessary and are reproduced in Fig. 1 to enable easy interpretations and comparisons to be made.

It was thought worth while to extend the area of application of the method briefly indicated by Sherwood and Pigford[1] (p. 229) to other mass-transfer data available in the literature. An additional set of curves connecting effective wetted surfaces with liquor rates (Fig. 2) was obtained.

The above-mentioned procedure for estimating effective wetted surfaces from mass-transfer data consists firstly of calculating the values of the groups

$$\frac{k_G a p_{BM}(Sc)^{\frac{2}{3}}}{G_M} \quad \ldots . (1)$$

from the available data corresponding to a series of modified Reynolds number values. The length dimensions in the Re quantities were taken as

$\sqrt{a_p}$ ft or $\sqrt{\text{surface area of one Raschig ring (sq. ft)}}$ —see Taecker and Hougen[11] or Sherwood and Pigford[1] (p. 228).

The translation of the Height of a Transfer Unit values quoted in the literature[6, 9] to Equation (1) involved the use of the relationship

$$\frac{1}{H.T.U_G} = \frac{k_G a P}{G_M} \quad \ldots . (2)$$

assuming that P and p_{BM} are for the purpose on hand both near to unity and that for the data of Parekh $H.T.U_{OG}$ and $H.T.U_G$ are equal.

Taecker and Hougen[11] give the experimental relations

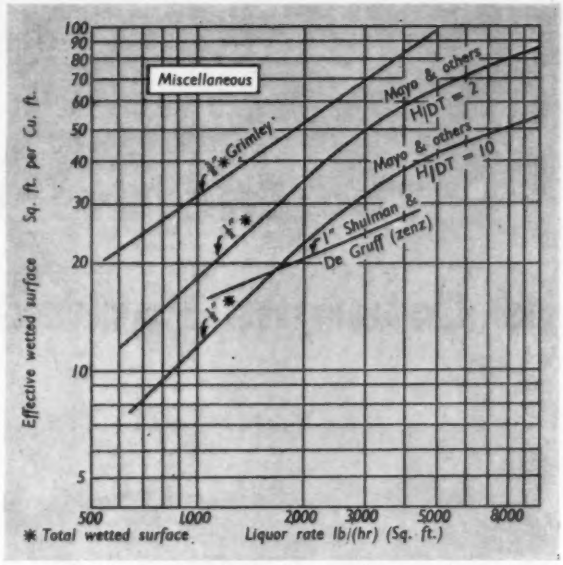

Fig. 1. Results obtained by various workers plotted for different liquor rates.

between j_D factors and Re values for fully wetted porous Raschig rings as:

$$j_D = 1.070 \left(\frac{G\sqrt{a_p}}{\mu}\right)^{-0.41} \quad \ldots . (3)$$

The j_D factor is defined (as reported by Sherwood and Pigford,[1] p. 61) as,

$$j_D = \frac{k_G p_{BM}}{G_M} \left(\frac{\mu}{\rho D_v}\right)^{\frac{2}{3}} \quad \ldots . (4)$$

The comparison of the values of Equations (1) and (4), for a given Re value, gives the value of a, the effective wetted surface. These particular units chosen are sq. ft/cu. ft.

Table 1 shows typical single-point estimations of effective wetted surfaces derived by analysing the data presented in the literature by Fellinger[8] and Parekh.[9] These data are given also in Sherwood[1] (p. 281-4) and McAdams[10] (p. 289). It appears that, within the several-fold range of Re values used, the effective wetted surface values can be logically averaged, so relatively small are the variations. Fig. 2 represents the curves from twenty-eight such averaged calculations.

Table 2 shows effective surface estimations derived from data[14] obtained in connection with hydrogen chloride absorption. The particular runs chosen were those which involved relatively cold absorbing liquor, as Kantyka and Hinkclieff[12] have shown that the adiabatic absorption of hydrogen chloride tends to produce anomalous effects in connection with packing wetting rates. The effective surface estimations are incorporated in Fig. 2 and appear to confirm the trend associated with 2-in. Raschig rings.

Average values deduced from all the results are plotted in Fig. 3. The maximum deviations from the directly determined wetted surfaces were associated with the very small (½-in.) rings. (The author[12] also found anomalous results for Ap values for small rings, which suggested that the rings were filled with stagnant liquor.) The relatively limited results associated with the determinations and the differing column dimensions are such that only a broad average, such as given by Fig. 3, is logically possible.

The literature of Pratt[7] and Morris and Jackson[2] contains data and methods of analysis useful for the determination of the minimum effective wetting rate for packings. The actual values proposed are expressed in various forms

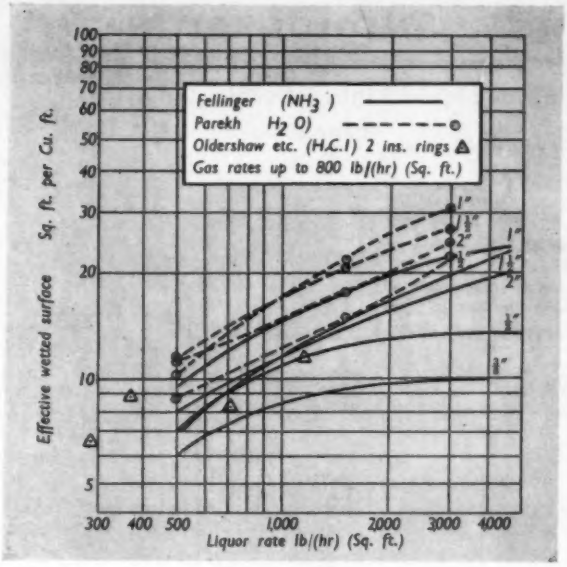
Fellinger (NH3)
Parekh H2O
Oldershaw etc. (H.C.I) 2 ins. rings
Gas rates up to 800 lb/(hr) (Sq. ft.)
Effective wetted surface Sq. ft. per Cu. ft.
Liquor rate lb/(hr) (Sq. ft.)

Fig. 2. Results obtained by the Sherwood and Pigford[1] method for effective wetted surface.

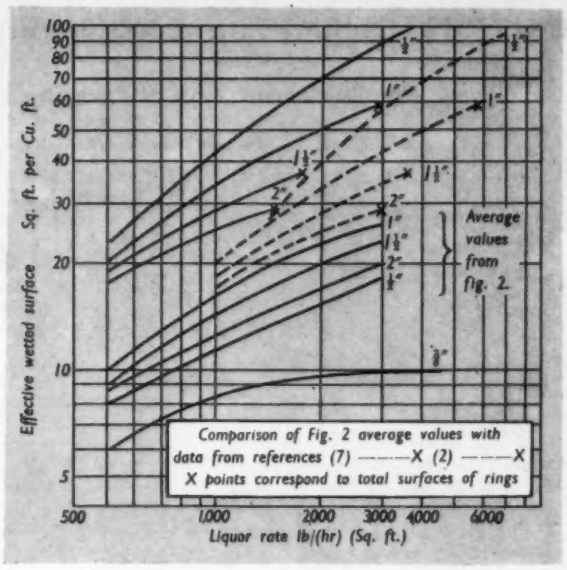
Average values from fig. 2.
Comparison of Fig. 2 average values with data from references (7) X (2) X
X points correspond to total surfaces of rings
Effective wetted surface Sq. ft. per Cu. ft.
Liquor rate lb/(hr) (Sq. ft.)

Fig. 3. A comparison of the average values given in Fig. 2, with data from Pratt,[7] Morris and Jackson[2]

and appear to be such that the resultant wetted surface is a useful proportion of that totally available. The maximum possible values, i.e., total geometrical surface of Raschig rings of various sizes, have been taken for the purpose of this paper as those quoted by Sherwood and Pigford[1] (p. 226) and appear as crosses on Fig. 3.

Pratt[7] (p. 208, Table IV) recommends various minimum effective liquid rates, up to a value of 1.7 cu. ft/(hr) (ft) for ammonia absorption. Morris and Jackson[2] (p. 22) recommend 0.85 cu. ft/(hr) (ft) as a minimum wetting rate suitable for rings up to 2-in. size. Morris and Jackson[2] (p. 56) also give a scale to enable a quantitative estimation of the effect of reducing the liquor rate. Details concerning the origin of this scale are not given. Using a combination of the scale values and assuming maximum available surface at the two proposed minimum liquid rates (converted to lb./(hr) (sq. ft) empty column), two sets of curves have been calculated and are presented in Fig. 3.

The general slope of all three groups of curves in Fig. 3 is approximately in accordance with the effect of liquor rate as suggested by Sherwood[1] (p. 285, Fig. 125), i.e., that the liquor rate effect is proportional to $(L)^{\frac{1}{3}}$. Table I and statements by Mayo and others[4] suggest that, below flooding, gas-velocity effects on surface wetting are negligible.

For convenience of comparison, on a single diagram of the sets of curves in Fig. 3 the ordinate limits of the two groups of minimum wetting rate curves were taken as the maximum available surface of the rings. No claim, however, is made by Pratt[7] (p. 198) that even at 1.7 cu. ft/(hr) (ft) liquor rate is the surface of rings wetted effectively to these maximum values. The curve arrangements make it simple to estimate the proportion of effective wetted surface compared with the total available surface using as a basis the average curves given in Fig. 2. From Fig. 3 it can be estimated that, at liquor rates corresponding to 0.85 cu. ft/(hr) (ft) of wetted ring perimeter, Raschig rings (of ½-2 in. diameter) are wetted effectively to 19-53% of their maximum available surface. For liquor rates corresponding to 1.7 cu. ft/(hr) (ft of wetted ring perimeter) this proportion rises to 26-70%. Norman[16] suggests that, with a liquor rate of 1080 lb./(hr) (sq. ft), 1-in. rings are wetted effectively to the extent of a 0.2 to 0.3 factor. This is borne out by Fig. 3, which gives a 17/58 or 0.29 factor.

The absorption towers used in all the reported works were of such a size (diameters about 2 ft, height up to 18 ft) that liquor distribution difficulties could be said to have approached those common to industrial-size plant.

Conclusions

It appears that the literature concerning experimental work upon the direct determination of the wetted surface associated with Raschig-ring-packed columns is limited. Rather more published information is available (as gas film controlled absorption data) which is amenable to analysis resulting in the indirect estimation of effective wetted surfaces. The directly determined wetted surface values for ⅜- and ½-in. rings appear to be considerably higher than the indirectly estimated effective values for the same size ring and liquor rate (as measured by liquor rate per unit cross-section of empty column). For a given liquor rate, the effective wetted surface per unit volume is surprisingly similar for Raschig rings ½-2 in. diameter, in spite of a 114/29 or approximately fourfold range of total available surface.

The liquor rate through a column has a considerable influence on the effective wetted surface available for mass transfer. The literature[2, 7] recommends certain minimum liquor rates for absorption systems calculated on ring sizes. At these liquor rates, Raschig rings of ½-2 in. in diameter are wetted effectively only to about ⅓-½ of the maximum available surface.

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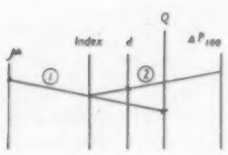
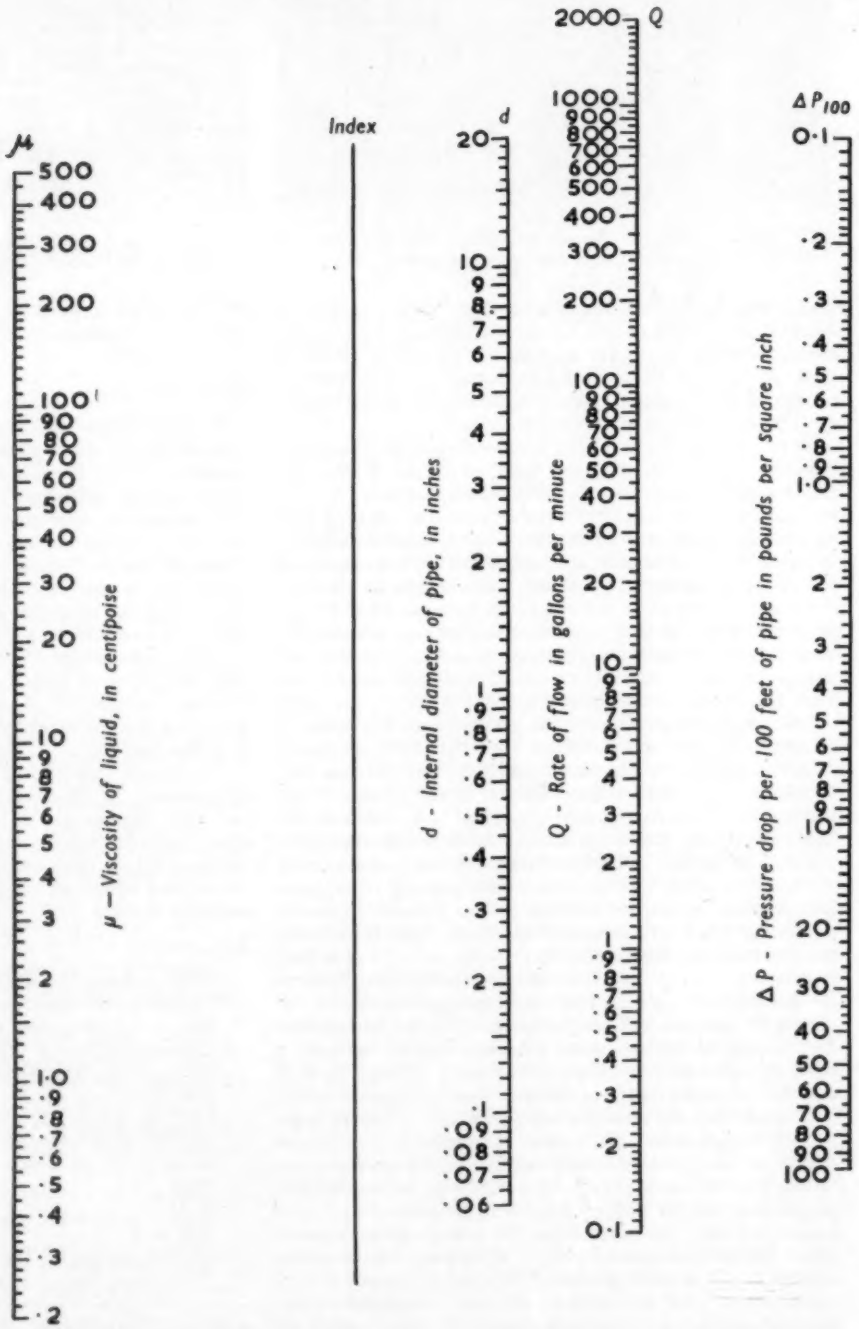
For Determination of Pressure Drop in Liquid Lines (Viscous Flow)

This nomogram is based upon the formulæ $\Delta P_{100} = \frac{0.0328 \mu Q}{d^4}$

in which ΔP_{100} = pressure drop per 100 ft of pipe in lb. psi;
μ = absolute viscosity of fluid;
d = internal diameter of tubing in inches; and
Q = quantity in gpm.

This chart supersedes Nomogram No. 3, which was published in *British Chemical Engineering*, 1956, **1**, 221. Before using this nomogram (No. 7) for a given problem, the Reynolds Number must be determined, either by formula or by means of a chart such as Nomogram No. 5 (*British Chemical Engineering*, 1956, **1**, 329). The method used is indicated below. The values for viscosity and quantity of fluid to be discharged, located on the μ and Q scales respectively, are connected, and the intercept on the index line noted. This point is connected to the pipe diameter on the d scale, and the pressure drop obtained from the extension of this line to the ΔP_{100} scale.





AMERICAN LETTER

Solar Energy

by Dr. Lincoln T. Work

This month our American Correspondent discusses the harnessing of solar energy as a new long-term power-source for industry

THE common fuels—coal, oil and gas—are vital to a nation's livelihood. These gifts of Nature have served us well in the past and will continue to do so in the future; but there is a limit to Nature's bounty. At the ever-increasing rate of fuel consumption, our eyes must turn elsewhere to find other ways to ensure long-term resources of energy. One source is solar energy. However, the old fuels are not finished yet. For instance, gasification of coal in the mine; the carbonisation of lignite; the cracking of oil shale; and the carbonisation of gilsonite are subjects of study to make for more economic use of the carbonaceous fuels.

The Phoenix Symposium

The past three or four years have shown a marked awareness of the harnessing of solar energy for the benefit of industry. In March, 1954, the Association of Applied Solar Energy was formed, and it is engaged in sponsoring this technology and advancing its applications. Under the joint sponsorship of the Association, the Stanford Research Institute and the University of Arizona, a World Symposium on Solar Energy was held late last year at Phoenix, Arizona, and a report of the Symposium was recently published and distributed by the Stanford Research Institute. The Symposium was preceded by a collation of world-wide activity in the subject, and a bibliography of the significant literature was published and distributed by the Stanford Research Institute, California, for the Association.

The many technical papers covering the diverse applications of solar energy presented at the Symposium indicated the extent of the practical engineering aspects of the problem. Solar machines, high-temperature furnaces, solar stills, house heating and cooling, heat pumps, water heaters, algæ and chlorella for food and feed, utilisation of solar energy by plants, and electricity from the sun were representative phases covered in the papers and discussion. From these it was clear that some of the suggestions proffered could be applied almost immediately.

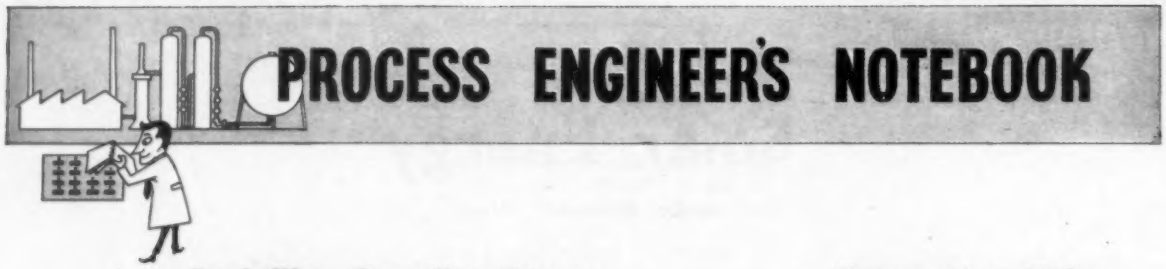
The high-temperature furnace is of considerable importance, and, although it is costly and cumbersome, it makes possible the concentration of solar energy. Moreover, the reactions going on at high temperatures can be studied and there may well be some that require temperatures and furnace conditions which this form of high-level energy can best meet. Dr. Jesse Hobson, then Director of Stanford Research Institute, presented a paper on "The Economics of Solar Energy". In about fifteen localities over the world, he assessed the factors of available sun's energy, prices of fuel, and labour and materials costs. At low consumption rates, solar energy compared favourably in some localities with the present residential electricity rates.

The development of sustained high temperatures has untold potential as a factor in chemical reactions. The oxy-acetylene torch gave, until recently, the hottest known flame (3400°K, 3130°C), but recent research on this problem has led to temperatures comparable to the 5000-6000°K at the sun's surface. To attain such sustained temperatures, the reaction must be highly exothermic and the products of combustion must be thermodynamically stable at the resultant temperatures. Because of dissociation of water to hydrogen and oxygen, the hydrogen-oxygen flame at one atmosphere is limited to 3000°K, which was also the limit for the alcohol-water-liquid oxygen fuel of the German V-2 rocket. Combustion of carbon and hydrogen compounds is likewise limited and, if air is used, is further limited by the heat needed to raise the temperature of the nitrogen fraction. Thus mixtures of carbon monoxide and air, and mixtures of natural gas and air, give temperatures of 2200-2400°K. However, reactions of hydrogen-fluorine at 4300°K, cyanogen-oxygen at 4800° and carbon sub-nitride-oxygen at 5300°K avoid these difficulties. Metals such as Be, Mg, Al, Ca, Zr, Hf and Th also give high flame temperatures with oxygen. Aluminum-oxygen yields 3800°K, while beryllium-oxygen reaches 4300°K.

Problems of Flame Velocities

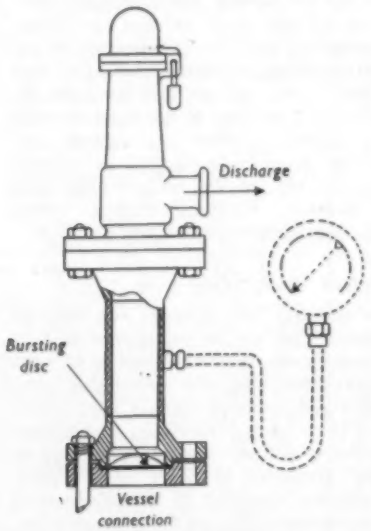
The oxy-aluminum torch is employed to cut through slabs of concrete rapidly. Gas torches using iron powder have been used for cutting stainless steel ingots. In both cases, the metal oxide works with the other slag components to give fluidity and to clear the cut for further action by the flame. With many gas reactions, dissociation is inhibited by pressure; thus flame temperatures may be 300-500°K higher for pressures of 10-40 atmospheres. Rapidity of burning also has a bearing on the compactness or capacity of the combustion unit, so flame-propagation velocities, often of almost explosive magnitude, present an opportunity and a challenge to the chemical engineer.

I would like to conclude this dispatch by referring to the stimulating article on solar energy which George O. G. Lof contributed to *Chemical Engineering* recently (September, 1956). Among other things, he discussed the use of solar energy as a low-temperature source for chemical production and its possibilities in the high-temperature field. Solar-energy stills for preparing fresh water from sea water were described by J. Leicester in the first half of his article on "The Purification of Saline Waters" (*British Chemical Engineering*, August, 1956, pp. 188-95). According to Mr. Lof, it is now possible to visualise the production of solar-distilled water at a cost of less than a dollar per thousand gallons. With regard to solar furnaces, he doubts whether these can compete at present with other types of high-temperature equipment, though he reckons that substantial cost reductions could be achieved, particularly if chemical engineers were to take a hand in this field of development.



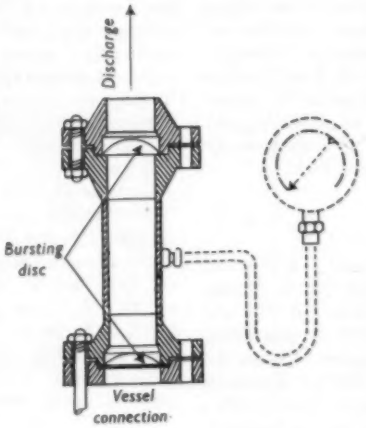
Installing Bursting Discs for Corrosive Conditions

THE USE OF bursting discs as pressure-relieving devices is widespread in the chemical industry. A bursting disc can be looked upon as a weak spot in the construction of a vessel and, as such, is fitted for the purpose of protecting the vessel and operating personnel from the danger of rapid rises in pressure. When there is no possibility of sudden rise in pressure inside a reaction vessel, the usual practice is to employ a safety



valve as a protective device. However, this practice is not satisfactory when the vessel to be protected contains chemicals that are likely to gum up or corrode the trim of the safety valve. One way of overcoming this difficulty is to install a bursting disc between the safety valve and the vessel in order to prevent contact between the vessel's contents and the safety valve only when the safe pressure has been exceeded. Similarly, when the conditions inside the vessel call for a bursting disc instead of a safety valve, the presence of corrosive chemicals is likely to weaken the disc and cause it to rupture prematurely. In such cases two discs in series may be used.

While such dual arrangements are generally satisfactory, they can give rise to a false sense of security. For instance, a very slight leakage at the primary disc through improper fitting,



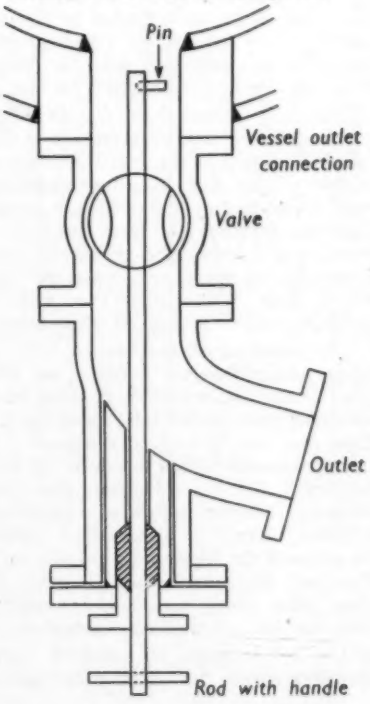
or through a minute hole, may lead to pressure development in the intermediate space. Again, it is possible, in the case of the safety-valve assembly, that a defective disc may act as a throttle to the flow of material leaving the vessel through excessive pressure. For this reason the pressure build-up inside the vessel will be in excess of that at which the safety valve is set to operate, assuming that the relief pressure is the same as the bursting pressure of the disc.

The situation may be worsened when the pressure inside the vessel is reduced, since this can cause the primary disc to dish inwards with the result that it will collapse at a much higher pressure than intended.

In view of the inherent risk in this dual arrangement, it is necessary to have either a method of detecting a slight leakage at the primary disc or a bleed-off connection at the intermediate space. The former may be accomplished by connecting a low-range pressure gauge to the intermediate space. In the case of the latter, a pipe connection, clear of the operating space, is the proper solution.

Preventing Valve Blockages

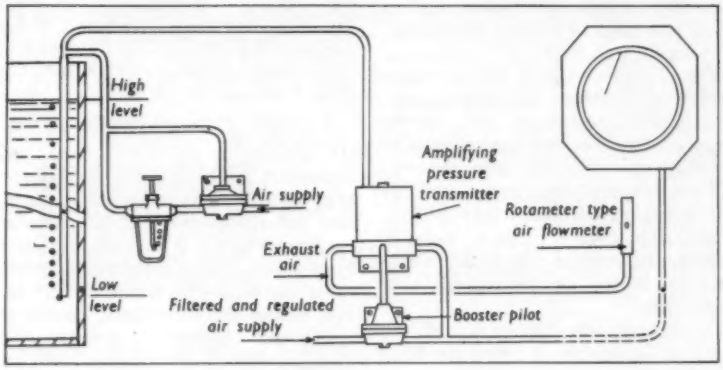
DIFFICULTY IS OFTEN experienced in discharging vessels handling slurries, especially if a small pocket at the valve allows solids to accumulate and block the exit from the vessel. It is possible to construct from standard fittings a rodding-through device to clear such blockages. Attached to the valve is a standard 45- or 90-degree bend, the branch forming the new exit for the vessel's contents. At the connection in line with the valve connection, a flange carrying a stuffing-box is attached. Through this is passed a rod (preferably of alloy steel to minimise sticking in the gland) and it should be of sufficient length to pass beyond the valve when the latter is open. It is an advantage to fit a small pin at the end of the rod to assist the clearing action and also to act as a stop. Sometimes it is worth while to install an Audco-type greaser at the gland to give some form of lubrication and also to minimise the sticking of the rod at the gland.

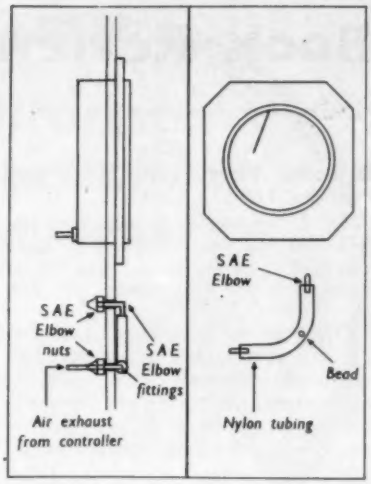


Inexpensive Purge Flow-meter

IT IS NOW common practice where pneumatically-operated automatic process controllers are installed to include on the instrument panel a small flow-meter to indicate that a particular instrument is working and that it is giving genuine readings on the instrument panel. The usual procedure is to fit the flow-meter on the purge line from the controller and immediately underneath the recording instrument working in conjunction with the controller. Generally, the flow-meter is a small rotameter type or similar variable area meter.

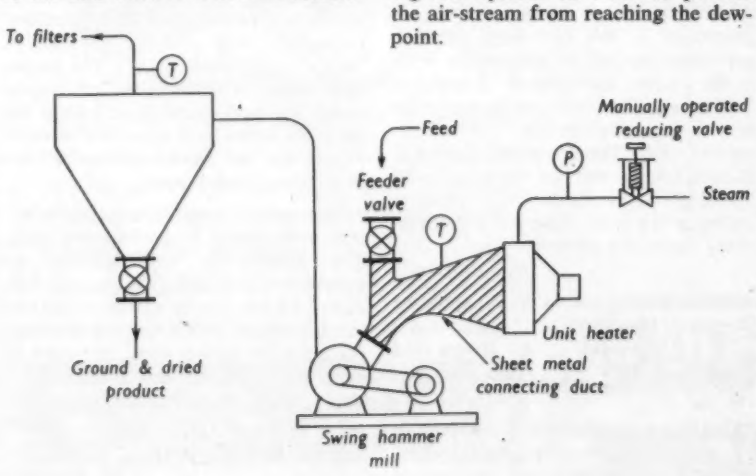
However, not all instrument panels are fitted with this kind of tell-tale instrument, and for those who wish to install an inexpensive flow-meter the following tip may be useful. A piece of transparent nylon tube is pushed on to S.A.E.-type elbows and the tubing bent at right angles. Two holes are then drilled in the panel underneath the recorder to which the purge refers. The purge-air connection from the controller is then attached to the lower connection. In operation, the flow is indicated by a small plastic coloured ball or bead which rises up the bend of the tube when air is flowing through it. (See above illustration.)





Space Heater Converts Hammer Mill to Flash-drier

THIS TIP MAY prove useful to the small manufacturer faced with the problem of drying and grinding a moist granular and heat-sensitive material. A small hammer mill of the once-through type, i.e., not including an external classifying circuit, may be converted to a drier by connecting the feed inlet to a suitably sized unit-heater. For this purpose a sheet-metal duct is required to connect the inlet of the mill at one end with the unit-heater at the other. At the inlet end of the mill there is a branch connection for attaching the rotary feeder-valve to the assembly. The entire additional equipment may be conveniently supported around the mill by means of a slotted-angle framework. If steam is used as the source of heat at the unit-heater, an inexpensive control of the element temperature may be obtained by means of a reducing-valve fitted with a hand-wheel for adjustment instead of the usual square- or hexagonal-ended spindle. It is necessary to lag the mill, ducting and cyclone in order to prevent the air-stream from reaching the dew-point.



Thermostats as Level Indicators

ORDINARY LIQUID level gauges or indicators are not always reliable when installed in vessels containing materials which have to be maintained at high temperatures to render them liquid, e.g., molten salts. Thermostatic switches may be a satisfactory answer in such instances. In one successful application the detecting ends in the thermo-switches are fitted inside tubular pockets attached to the vessel. The number used depends upon the type of indication required. In some instances, where a high-low type of alarm is all that is required, a system of three thermostats will be sufficient. Each is connected to a source of electrical power in series with a suitable indicator light, such as a small neon lamp. The lamps may be mounted on a panel in positions corresponding to the levels they represent in the vessel. In practice, the thermostats are set at a temperature very slightly below that of the liquid, so that those submerged will open the electrical circuit and cause the associated lamps to be extinguished. The elements above the liquid will have their contacts closed so that their lamps will light up. It is possible with the high-low arrangement for the switches to be a part of a system of control for pumps or valves.

Book Reviews

Hydrogen Peroxide. A.C.S. Monograph No. 128

by W. C. Schumb, C. N. Satterfield and R. L. Wentworth

Reinhold Publishing Corp., New York; Chapman & Hall Ltd. London, 1956. 773 pp., 132s.

THE subject of hydrogen peroxide has grown to such considerable proportions in recent years that there has become an urgent need for some authoritative book to be published in English on the subject. The product is now manufactured on a very large scale in all strengths up to 90% by weight and recently there has been a patent claiming the continuous production on a commercial scale of an almost anhydrous product. Hydrogen peroxide has now a wide range of applications and there are few industries which do not come into contact with it in one way or another. It is, therefore, timely that the available information should be collected in one volume and this book presents an excellent review of the modern position and may become a standard reference book for some years to come.

The authors are eminent American academic workers who became interested in hydrogen peroxide as a result of developments in the manufacture and uses of high strength solutions.

The many aspects of hydrogen peroxide have all been dealt with. The basic chemistry has been particularly well treated and the collection of data on the physical and chemical properties together with the detailed discussion on reactions must be of value in some way or another to every worker concerned with the product. One of the authors, Prof. Schumb, has made a special study of the stability property which is reflected in the sound and reliable way in which this problem is dealt with.

The chemical engineer will find much of interest and value in the first few chapters, particularly the information on manufacture, materials and physical properties. From a purely technological point of view, the subject matter is essentially published information and is therefore a descriptive review of technological methods with bias on German practice.

The details of preparation and manufacture are covered very throughly and should be of particular interest to those who are not familiar with hydrogen peroxide by showing the varied methods which have been applied or investigated at one time or another. The principal industrial methods are described in some detail. These include the various modifications of the barium peroxide process which is now almost obsolete, the variations of the electrochemical process and the autoxidation method which has been developed recently to large-scale production.

It is of major importance to appreciate the behaviour of materials in contact with hydrogen peroxide to ensure satisfactory storage and handling and the chemical engineer will find much useful data in this connection. There is, however, relatively little plant design data principally because such information is not freely available to those not associated with production.

In view of the importance of the effect of impurities on the product, the chemist would no doubt have welcomed more details of the analytical techniques, particularly those used in industry.

The chapter on uses shows the many varied applications, but the subject is dealt with a little sketchily in that there are few actual details of the methods used for many of the applications. However, this chapter includes references to the majority of uses covering the traditional application in the textile field, the use as an oxidising agent in the production of organic chemicals and the applications of high strength hydrogen peroxide as a source of energy.

It is a well written book presenting the subject in an interesting way. The authors have completed their task in a most thorough manner which is illustrated by the very large number and complete set of references, both to the papers and individual authors. It is an excellent addition to the series of monographs which have been sponsored by the American Chemical Society and in view of the varied and valuable applications of hydrogen peroxide the book deserves a place in every technical library.

W. S. WOOD

A Course in Modern Techniques of Organic Chemistry

by R. P. Linstead, J. A. Elvidge and Margaret Whalley

Butterworths Scientific Publications, 1955. 190 pp., 25s.

THIS book describes the course in experimental techniques instituted in 1951 at the Imperial College of Science and Technology for the benefit of undergraduates specialising in organic chemistry and of new research students from other institutions. There is a number of voluminous books offering specialist treatment of various techniques. This little book is different: it deals with a variety of modern techniques essential in organic research, introducing each with a very brief and simple account of the theory underlying it, describing fully the apparatus required and giving exercises designed to assist the student in learning the technique. It thus fulfils two most important functions: it fills the lacunæ in the practical training of the average graduate and brings the older graduate up to date.

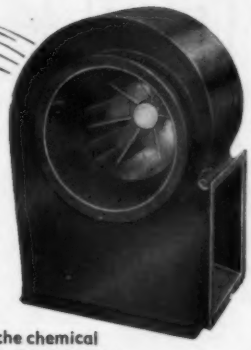
The book is divided into three parts:

(1) techniques of purification and separation, involving those of adsorption-, partition-extraction by paper- and ion-exchange (but not vapour) chromatography, fractional extraction by counter-current distribution and the older techniques of fractional distillation (under the ingeniously contrived, controlled reduced pressure); (2) special reaction techniques, such as hydrogenation at atmospheric and high pressures and vapour phase reaction; (3) techniques of quantitative analysis, potentiometric titration, "Spekker" analyses, absorption spectrometry, etc. This last part includes techniques (e.g., carbon and hydrogen determination) which may prove difficult for the research worker not conversant with analytical procedures. This book is a store of practical hints (e.g., the purification of solutions by filtration through a kieselguhr and charcoal bed (p. 58) instead of the customary and wasteful addition of the absorptive material to the solution followed by filtration; the undesirability of silicone grease for head joints in reduced pressure distillations) and of simple devices (e.g., for hot and cold filtrations, p. 59). Safety precautions are highlighted throughout (e.g., the use of shielded vacuum desiccators, p. 12). The names and addresses of suppliers of instruments and equipment described in the book are given and also references to papers and text-books concerned with the various techniques.

The book is unpretentious, informative, and written in an informal style. The illustrations and legends are generally clear. The authors and their collaborators can be warmly congratulated on most ably satisfying an existing need for such a book. It would be surprising if the book were not accepted as an essential part of the equipment of the modern organic laboratory.

M. PIANKA

The fan for the Chemical Industry



This is the fan that resists the chemical action of strong acids, alkalis and moist gases. Steel outer casing. Impeller constructed from rigid P.V.C. and all metal surfaces protected with same material. We design and install complete plants including P.V.C. Ducting and Hoods. Let us have details of your requirements.

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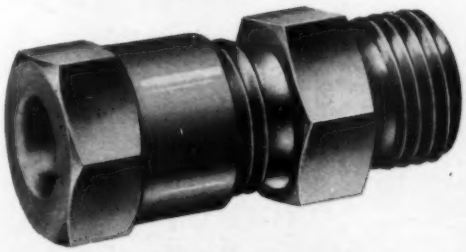

Flareless Pipe Coupling

Suitable for use with copper, steel, stainless steel, etc. In o.d. sizes up to 1". Suitable for working pressures up to 4,000 p.s.i. Available in the usual types, i.e. stud couplings, straight couplings, elbow and tees.

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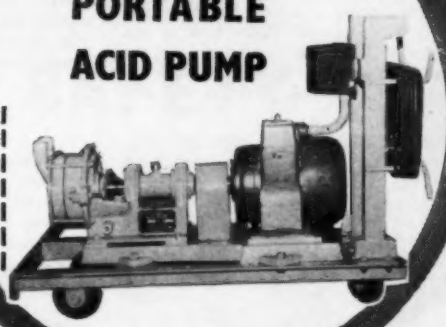
MITCHELL PORTABLE ACID PUMP



CAPACITY 780 G P H; TOTAL HEAD 25 FT, INCLUDING A SUCTION LIFT EQUIVALENT TO 10 FT OF WATER; STANDARD UNIT FITTED WITH 1½ H P MOTOR FOR 400/440/3/50 ELECTRICAL SUPPLY

CONSIDER THESE ADVANTAGES

EASILY PORTABLE The pump is mounted on a substantial fabricated trolley having rubber tyred wheels and rear castors, so that it is easily portable to any part of the factory.

SELF CONTAINED The complete assembly includes the motor starter mounted on the trolley frame and permanently wired to the driving motor. The flexible cable provided is conveniently wound on supports from the trolley, so that it is only necessary to plug in at any power point for immediate operation.

SELF-PRIMING The pump is completely self-priming and requires no additional valves or foot valves for its operation. Designed for use with flexible hosing, it is only necessary to place the piping in position and switch on the pump for immediate operation.

UNIVERSAL APPLICATION Being constructed in special corundum material, the pump will deal successfully with all acids, except hydrofluoric, at any concentration and with all alkalis. In addition, it can of course be used for more conventional water pumping duties, and is therefore a pump of almost universal application in many works for odd pumping duties.

WIDE RANGE OF DUTIES The pump can be used for emptying sumps of acids or combinations of acids in waste effluents, emptying carboys, plating vats, tanks and vessels, and for the discharge of road tankers, etc.

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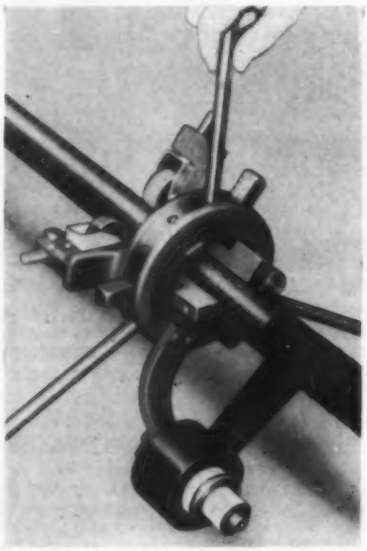
PLANT EQUIPMENT NEWS

Mechanised Pipe-lagging

A pipe-lagging machine has been developed by Industrial Tapes Ltd. It has a quick-acting and self-centring gripping device, so that once the machine is locked in the required position the lagging is carried out with the correct overlap throughout the length of run. A scale provided with the machine shows the setting required for various diameters of pipe, widths of tape, and the degree of overlap required. Speedfix tapes suitable for use in these machines protect against moisture, acids and alkalis. **Industrial Tapes Ltd., Speedfix House, 142/146 Old Street, London, E.C.1.**



BCE 562 for further information

Glass Air Filters

Exclusive selling rights in Great Britain for the Amer-glas industrial air-filter of the American Air Filter Co. have been obtained by Air Control Installations. The glass wool used in the filter is formed of continuous, slightly curled, interlaced filaments held in place with a thermoplastic bond. Filter capacity is based on a rating of 2 c.f.m. per sq. in. of filter area at the recommended velocity of 300 ft per minute. **Air Control Installations Ltd., Victoria Road, Ruislip, London.**

BCE 563 for further information

Three-way Diaphragm Valves

A three-way diaphragm valve which is claimed to be the first of its kind in the world is now available from Talbot Stead. It is simple to operate and is fitted with a selector device that clearly indicates which side of the valve is closed. As there is no mechanism in contact with the fluid, the valve is of special use in the food and allied industries. **Talbot Stead Tube Co. Ltd., Green Lane, Walsall, Staffs.**

BCE 564 for further information

Pilot Valves

A range of pilot valves for air, hydraulic and vacuum working is being produced by the Pneumatics Division of Baldwin Instruments. Three- and four-way valves of bore size ¼ in. are available with a choice of the following operating mechanisms: push-button; cam, single pilot; double pilot; plunger; and switch. The valve bodies and fittings are made of Duralumin, anodised to increase resistance to atmospheric corrosion. The valve spools are of mild steel, precision ground and hard chromium-plated. Standard units are suitable for use with air or mineral oils at pressures up to 250 lb./sq. in. **Baldwin Instrument Co. Ltd., Brooklands Works, Dartford, Kent.**

BCE 565 for further information

Pneumatic Conveyor

Blaw Knox have just developed the "Auto-Airflow" pneumatic conveying equipment for powders, fine granular and flaked materials. Adaptability is a feature of the equipment which the manufacturers emphasise, and the system has already been used successfully for the conveyance of materials as diverse as cement, detergents and resins. The equipment can be supplied in forms which meet food-handling regulations. A research and testing plant is maintained by the company to determine the suitability of customers' materials for pneumatic conveyance, power requirements and output rates. **Blaw Knox Ltd., 94 Brompton Road, London, S.W.3.**

BCE 566 for further information

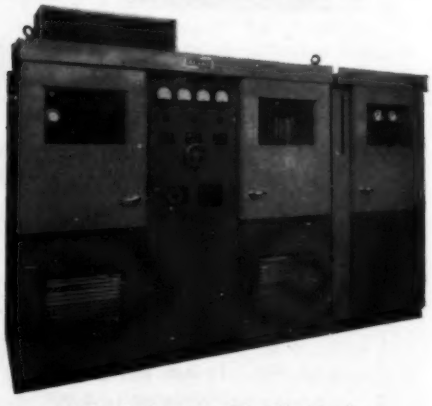
Corrosion Inhibitor

The use of cyclohexylamine carbonate as a vapour-phase inhibitor of corrosion was first proposed and studied at the Chemical Research Laboratory, Teddington. In moist air and in the presence of small quantities of sulphur dioxide the compound suppresses or reduces the corrosion of steel, cast-iron, aluminium, zinc, tin-plate, chromium-plate and solder. It may, however, promote the corrosion of copper and its alloys, especially in the presence of condensed moisture. Compared with other commercially available volatile corrosion inhibitors, CHC has a rather high vapour pressure (0.3 mm Hg at 20°C). It is specially useful, however, for rapidly providing short-term protection, or for protecting large enclosed spaces like the water-and-steam side of idle boilers. **Howards of Ilford Ltd., Ilford, Essex.**

BCE 567 for further information

Dielectric Heat-generator

A new, high-power dielectric heat-generator, the Radyne, has just been released by Radio Heaters. The unit is designed to be used singly or in batteries feeding an oven with a conveyor running behind a row of units. Each unit is capable of delivering 45 kW continuously at a frequency of 18 to 20 mc/s. Each unit is therefore capable of removing 120 lb. of moisture per hour from materials which are difficult to dry in other ways. The makers claim that the new unit is the largest of its kind to be in regular production outside the U.S.A. **Radio Heaters Ltd., Eastheath Avenue, Wokingham, Berks.**



BCE 568 for further information

Humidifiers

Two models of humidifiers have been introduced by A. & A. The new transportable model is mounted on wheels for easy movement to any part of the store or workshop requiring humidification.

No other synthetic construction material combines the chemical resistance of COBEX with such ease of fabrication and low manufacturing cost.

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RIGID VINYL SHEET

The use of COBEX means greater safety for industry, for this all-British rigid vinyl protects workers and plant from the effects of corrosive fumes caused by acids and gases. COBEX is used for chemical plant throughout the world.
Those interested in industrial safety are invited to inspect the equipment illustrated—as exhibited at the Engineering Section of the 1956 B.I.F.— at the Industrial Health and Safety Centre, 97 Horseferry Road, London, S.W.1.

Tank lined with Cobex/Velbex laminate by A. E. Griffiths (Smethwick) Ltd. Lip ducting Trunking and cowl by Prodorite Ltd. Fan fabricated in Cobex by Tanks and Linings Ltd. for Keith Blackman Ltd.

BX PLASTICS LIMITED

A subsidiary of The British Xylonite Co. Ltd. HIGHAM STATION AVENUE, LONDON, E.4. *LARKSWOOD* 5511

PLANT EQUIPMENT NEWS

It is constructed from aluminium and stainless steel, and contains a filter which cleans the air before recirculation. The aerosols are produced by water being pumped in a thin film on to a spinner which, in turn, throws the water against fixed blades. Powered by a 2-h.p. motor, the machine atomises approximately 4 gallons of water per hour. The new wall model is powered by a 1-h.p. motor and has an output of approximately 2½

gallons per hour. **A. & A. Industrial Equipment Ltd., 5-7 New York Road, Leeds, 2.**

BCE 569 for further information

Mixing Controller

A demonstration is to be arranged during December of the Select-O-Weigh automatic proportioning system which was originated by Richardson Scale, of U.S.A., and is now being manufactured and marketed in Britain by Henry Simon. The system is applicable to a variety of industrial processes in which materials are mixed into batches, and it brings under the control of a central panel the whole of the feeding, weighing, mixing and discharging cycle. The weights of ingredients may be regulated manually with dials or automatically by a punched-card device. Applications to attend the demonstration should be made to: **Henry Simon Ltd., Cheadle Heath, Stockport, Cheshire.**

BCE 570 for further information

Smoke Meter and Alarm

Efforts being made to reduce atmospheric pollution and, indeed, loss of fuel through smoke production often call for the use of smoke-measuring equipment. Two kinds of relevant equipment—an alarm for indicating when the smoke density in a flue exceeds a pre-set limit, and a more elaborate installation which continuously monitors and records the smoke density—have just been made available by A. M. Lock. The mechanism of both installations includes a light source that directs a beam of light across the flue gases on to a photo-electric cell. Electrical changes in the cell which follow variations in the light received are magnified in an electronic control unit mounted in a dust-tight aluminium case in the boiler room. Apparatus can be supplied which rings an alarm bell when the smoke density exceeds Ringelmann 2, or can, in addition, record the smoke density on a circular chart (for a 24-hour period) or on a strip (for periods of one month). The recording unit also counts the number of alarms given and shows the total time for which the equipment has been operating, and for which the alarms sounded. Puffs of smoke corresponding to Ringelmann 2 or greater do not sound the alarm if their duration is less than five seconds. Built-in air jets in the light projector and receiver houses keeps soot deposits on the glass to a minimum. **A. M. Lock & Co. Ltd., 79 Union Street, Oldham, Lancs.**

BCE 571 for further information

Graphite Heat Exchanger

A new graphite heat exchanger, the Polybloc, has been made available by Le Carbone (Great Britain). It consists of a pile of impermeable cylindrical graphite blocks having two sets of flow passages for two heat-exchange fluids. One set is parallel to the axis and the other is arranged radially. Elastic gaskets between the blocks prevent contact between the separate fluids; the complete pile is held in compression by top and bottom headers and exterior tie bars. The outer casing is formed of sectional metal ring-shaped elements bolted together. **Le Carbone (Great Britain) Ltd., Portslade, Sussex.**

BCE 572 for further information

Pressure Regulators

A new range of seven slack-diaphragm-operated pressure controllers is announced by George Kent. They are all of the non-indicating, non-recording, blind-setting type, and comprise suction or pressure controllers, including a special-purpose furnace-pressure controller; differential-pressure controllers; a special-purpose mill controller; and an air-flow controller or differential-pressure transmitter. The general appearance of all these instruments is similar. The instrument door measures 18 × 15 in., and the instruments are suitable for wall, panel or post mounting. **George Kent Ltd., Luton.**

BCE 573 for further information

Flexible Tube

Flexflyte is a lightweight, flexible ducting fabricated in a range of materials which will withstand pressures of up to 70 psi internally and 15 psi externally. Higher pressures can be catered for. The ducting is designed to withstand temperatures ranging from 120 to 650°F. Its main feature is its flexibility, which enables it to be bent through 180 degrees. There is a range of standard diameters from ¼ to 4 in. bore. Standard lengths are 12 ft for diameters over 1 in., or 8 ft for the smaller sizes. Flexflyte is supplied with an inner lining of synthetic rubber, coated fibre-glass, or cotton. There are four standard types of coating with different resistances to internal temperature, designed for use with a great variety of solids, liquids and gases. The coverings and their temperature resistances are: PVC, 65 to 180°F; Neoprene 65 to 350°F; nitrile, 65 to 400°F; and silicone rubber, 120 to 650°F. **Flexible Ducting Ltd., Maryhill, Glasgow, N.W.**

BCE 574 for further information

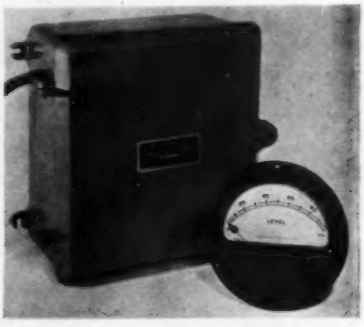
Volume Controller

In the operation of the new photocell liquid-level control by Airmec, two light beams are broken at the higher level and are both continuous at the lower level. The instrument therefore needs no contact with the liquid or material entering the storage unit. Consequently, the characteristics of the liquid are unimportant and the instrument may readily be used for the control of even highly corrosive liquids or materials at high temperatures. **Airmec Ltd., High Wycombe, Bucks.**

BCE 575 for further information

Level Controllers

Two new level-controlling instruments based on the principle of electrical capacitance, for use with solids or liquids, have been made available by Fielden. The Tektor J.3 instrument is a development of the J.1 model which has been on the market since 1951. It is robust in design and contains a simple oscillatory circuit which, when subject to a change of electrical capacity, operates a relay for the control of electrical contactors, visible and audible alarms. The type J.3 is housed in a die-cast aluminium case, whereas type J.5 is enclosed in a weatherproof sheet-metal case for more



arduous industrial conditions. Flame-proof models are also available. For the continuous indication of level, the Telstor L.F.3 instrument has been developed, (see illustration on this page) and with the use of suitable indicators can be made to show the content of a vessel at points up to half a mile away from the plant. **Fielden Electronics Ltd., Paston Road, Wythenshaw, Manchester, 22.**

BCE 576 for further information

First Phillips-type Polyethylene Plant for Great Britain

BRITISH HYDROCARBON CHEMICALS LIMITED has awarded the contract for its polyethylene plant to the Stone & Webster Engineering Corporation.

As the British affiliate of the corporation, Badgers will do all detailed design work for the plant, procure the equipment and supervise the construction.

The new plant will produce about 11,000 tons per year of polyethylene, using the low pressure process developed by the Phillips Petroleum Company. It will be located at Grangemouth, Scotland and will receive its feed from the existing ethylene plants designed by Stone & Webster and built by Badgers.

E. B. BADGER & SONS LIMITED

Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

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Affiliated with STONE & WEBSTER ENGINEERING CORPORATION, U.S.A.

PLANT EQUIPMENT NEWS

Other Items of Interest

A simple, quick and inexpensive method of recording the result of magnetic metal-flaw detection has been developed by Industrial Tapes in association with Radalloyd Ltd. **Industrial Tapes Ltd., Speedfix House, 142/146 Old Street, London, E.C.1.**

BCE 577 for further information

An Epikote-based paint, Pitakote, which is claimed to provide outstanding resistance to acids and alkalis, solvents fatty acids and to abrasion, and to possess notable gloss, adhesive, flexibility and hardness properties has been made available by **Allweather Paints Ltd., 36 Great Queen Street, London, W.C.2.**

BCE 578 for further information

A new design of resistance thermometer, having an accuracy of ± 1°C and a sensitivity of ± 0.1°C, is available from **Savage & Parsons Ltd., Watford, Herts.**

BCE 579 for further information

A new type of asbestos anti-corrosion emulsion coating, Flexikote, which can withstand continuous exposure to a temperature of 200°F, is now available. It may be applied by brush or low-pressure spray, and while becoming dry-to-handle after 24 hours, it remains slightly tacky indefinitely. **Solvolene Lubricants Ltd., Reginald Square, London, S.E.8.**

BCE 580 for further information

Goodlass have introduced a grey industrial paint formulated primarily for the protection of steel structures but equally applicable for coating other structural surfaces in factories, warehouses, power stations, etc. **Goodlass, Wall & Co., Wellington Buildings, The Strand, Liverpool, 2.**

BCE 581 for further information

Preliminary details have been announced of a new Manesty all-purpose comminuting machine. It is equipped with swinging impact-blades and may be operated at a wide range of speeds. **Manesty Machines Ltd., Speke, Liverpool, 19.**

BCE 582 for further information

SEEN AT THE FUEL EFFICIENCY EXHIBITION

Thermal Storage Boiler

Considerable economy in fuel and improvement in factory output are advantages claimed in the use of a new thermal storage boiler developed by Edwin Danks, based upon patents held by Dr. E. G. Ritchie. The boiler combines steam-raising and heat-accumulation, so that its water volume acts like a thermal flywheel, storing heat by a controlled rise in water level during periods of low steam demand, and releasing this heat by a drop in water level to meet the peaks. It enables peaks of 25-40% above the average steam demand to be met without change in process steam-pressure and without change in firing rate. An efficiency of 80% has been recorded in practice, and an increased output of 10-15% per unit of time compared with the performance of conventional boilers, is claimed for the boiler. **Edwin Danks & Co. (Oldbury) Ltd., Oldbury, near Birmingham.**

BCE 583 for further information

Steam Generator

Manufacture in Britain of the Stone-Vapor team generator has just commenced under licence from Vapor International Corporation Ltd., Chicago. The generator is a compact, forced-circulation, water-tube boiler with several sets of coils nested and connected in series to form a single coil of steel tubing. The boilers are about one-quarter the weight and one-fifth the size of conventional boilers of the same rating. The makers claim that within two minutes, from a cold start, a generator can develop 200 lb. steam pressure. Models with adjustable pressure controls are supplied suitable for the following ranges of pressure: 5 to 15, 50 to 100, 50 to 150, 75 to 275 and up to 575 lb./sq. in. The normal rating is from 1000 to 45,000 lb. of steam per hour from single units. **J. Stone & Co. (Deptford) Ltd., Arklow Road, London, S.E.14.**

BCE 584 for further information

De-ionised-water Plant

A small, engineering-scale, mixed-bed de-ionising plant, which has just been developed, was shown by Permutit. The bed is 6 in. in diameter and yields 100 to 1000 gallons of de-ionised water per regeneration. The controls of the plant are grouped in a panel, and the instruments include a flow indicator and conductivity meter—the full deflection of which is equivalent to 4 micromhos. **The Permutit Co. Ltd., Permutit House, Gunnersbury Avenue, London, W.4.**

BCE 585 for further information

Simple Modulator

A new and simple modulator which can be used to control any process that uses or could use dial-type instruments and that does not require an instantaneous response was shown by Combustion Equipment. The essential component in it, the Watson modulator, is a free-moving detector which is intermittently scanned by a potentiometer for change of condition, e.g., of pressure, temperature, rate of flow. The modulator, in fact, contains only simple electrical components (transformers, rectifiers, relays and potentiometers), which operate on a bridge principle and control torque motors mechanically coupled to the feed device of the plant. The detecting mechanism is virtually frictionless, and by adjustment of the switching motor can be made to operate over a wide range of frequencies and periods (usually four to eight times per minute). **Combustion Equipment Ltd., 61 Belsize Lane, London, N.W.3.**

BCE 586 for further information

Heat Transfer Switch

A new liquid-level switch operating on a novel principle has been developed by Teddington Industrial Equipment for the control and indication of liquid level in tanks, boilers, sterilisers and other types of industrial vessel. The switch, designated type WX, has no moving parts and operates on a difference in heat transfer between the sensitive element and the liquid in the vessel, or the vapour. It gives a sensitive response, changes of level in the order of ¼ in. being sufficient to operate the switch, and the mechanism is unaffected by temperatures from 0 to 350°F. Two models are available offering alternative methods of mounting. **Teddington Industrial Equipment Ltd., Windmill Road, Sunbury-on-Thames, Middlesex.**

BCE 587 for further information

Other Items of Interest

Developments in heat-insulating materials included a new preformed, high-temperature pipe-section of Versil glass-fibre, which has given satisfactory continuous service for seven months at a temperature of 1000°F. **Versil Ltd., Rayner Mills, Liversedge, Yorks.**

BCE 588 for further information

Super magnesia heat-insulating medium, a development of the 85% magnesia available from The Chemical & Insulating Co., is claimed to be lighter and stronger than the parent substance. It may be moulded to the exact pipe size. At present it is only available in limited quantities. **The Chemical & Insulating Co., Ltd., Darlington, County Durham.**

BCE 589 for further information

Pioneer insulating plasterboard, which differs from the established forms of Pioneer board in having a bright metal heat-reflecting surface stuck to one face, was shown for the first time by **Imperial Chemical Industries Ltd., Imperial Chemical House, Millbank, London, S.W.1.**

BCE 590 for further information

The new Mowbrey electric Hilo level alarm for use in boilers and other vessels operating with pressures up to 650 lb. psi

WATER COOLING plus
Guaranteed performance
THE PERFORMANCE of 'Counterflo' cooling towers can be specified to within a few degrees of wet bulb temperature in a guarantee which affords the user full protection.
Prefabricated timber or precast concrete cooling towers by Head Wrightson provide unequalled performance for a low capital outlay and minimum running costs.
H.W.P. operate an Inspection Service which ensures that cooling towers, once installed, continue to operate at maximum efficiency throughout their lives. Details of this service will be supplied upon request.
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P8283

PLANT EQUIPMENT NEWS

was shown by Trist. It is a glandless, magnetically operated fitting, embodying a stainless steel float and centre tube (which shrouds the float magnet). The mercury switches of the instrument possess independent contacts for operating the alarm and firing cut-out. **Ronald Trist & Co. Ltd., Bath Road, Slough, Bucks.**

BCE 591 for further information

The largest spiral vibratory conveyor so far to be made by Owl Engineering was on show. It was 18 ft in height, had a capacity of 12 tons per hour, and was energised by fractional horse-power motors driving out-of-balance weights rotating in opposite directions. **Owl Engineering Supplies Ltd., 16 South Parade, Doncaster.**

BCE 592 for further information

SEEN AT THE ENGINEERING INDUSTRIES EXHIBITION

Drum Filler

The Astral-Rockwell thermostatically-controlled drum filler now being made in Britain under licence was shown by Ladley. The British-made model embodies modifications of the original American design, and is, in fact, supplying the U.S. as well as the home market. The machine's thermostatic control automatically ensures accuracy of measurement, regardless of the expansion or contraction of the fluid measured. The filler operates at pressures up to 150 lb., and shut-off is automatic. There are two models. Model A has a 2-in. meter and a range of from 30 to 100 gallons, and model B is equipped with a 1½-in. meter, and can measure 5 to 30 gallons. All metal parts are of corrosion-resistant alloys selected for the particular fluid to be measured. **A. S. Ladley & Co. Ltd., 3 Crompton Way, Crawley, Sussex.**

BCE 593 for further information

Simple Filter

A prototype of a simple, inexpensive filter designed primarily for electroplating solutions was shown by British Filters. It is composed essentially of a series of plates arranged in a vertical column and capable of holding a variety of filter media. The capacity of the filter is 500-600 gallons per hour. The case is ebonite-lined and the external wall lead coated, and the whole filter is resistant to liquids within the range of *p*H 1 to 13, and to temperatures up to 180°F. **British Filters Ltd., Old Court, Cox Green, Maidenhead, Berks.**

BCE 594 for further information

Pressure Switch

An indicating pressure switch with a separate pre-setting dial and an automatic safety device which "blows" electrical circuits at pre-set pressure readings has been developed by Appleby & Ireland. The instrument contains two sensing units—one for indication, and a second working independently and, therefore, avoiding any danger of the setting being altered by the movement of the mechanism, an alarm setting and pressure switch. The instrument may be fitted with a heater if required, for use at 60°C. **Appleby & Ireland Ltd., Kempshott Park, Basingstoke, Hants.**

BCE 595 for further information

Other Items of Interest

A new reflex projector which may be used for viewing component edges in profile or for examining surface phenomena has been developed by Baty. Designated the No. 1 Reflex projector, it is of the "bench" type with a vertical screen placed immediately above the work stage. The screen is 12½ in. in diameter and may be turned through 360 degrees. **J. E. Baty & Co. Ltd., 39 Victoria Street, London, S.W.1.**

BCE 596 for further information

A recording modification of the K.D.G. hydrostatic liquid contents gauge has been produced. Like the gauge, it operates through a sealed system, and is activated by the pressure head on a diaphragm. **K.D.G. Instruments Ltd., Purley Way, Croydon.**

BCE 597 for further information

Moving-coil relays can now be supplied by **Measuring Instruments (Pullin) Ltd., Electrin Works, Winchester Street, Acton, London, W.3.**

BCE 598 for further information

New electronic small-motor controls have been developed by **S. Brod & Co. Ltd., 31-33 Priory Park Road, London, N.W.6,** and **The Medical Engineering Co. Ltd., 4 Fountayne Road, Broad Lane, Tottenham, London, N.15.**

BCE 599 for further information

A new design of self-emptying elevator bucket has been elaborated by Airnesco Products. Each bucket contains a weighted rubber lining, which falls out when the bucket is inverted, and drops back into place again when the bucket resumes its carrying position. A patent application has been made for the invention. **Airnesco Products Ltd., Strood, Rochester, Kent.**

BCE 600 for further information

New Publications

Corrosion Proof Products Ltd., Great West Road, Brentford, Middlesex, have prepared some notes on the causes of chemical attack on industrial floors and have published these notes in service sheet form (No. 101).

BCE 601 for further information

F. A. Hughes & Co. Ltd. have published two brochures on "Cathodic protection of chemical plant". (Publications 74 and 76.) Copies can be obtained from the company. (Devonshire House, Mayfair Place, Piccadilly, London, W.1.)

BCE 602 for further information

"High-vacuum Rotary Piston Pumps" is the title of a new four-page brochure produced by N.G.N. Electrical Ltd. (Cawdor Street, Patricroft, Manchester) and which describes their P.S.R. and P.D. range of rotary piston pumps.

BCE 603 for further information

Folder D.3 is a four-page informative brochure on the Wynn straight-through diaphragm valves. Suitable for handling large range of fluids, these valves are self-draining, require no packing, and there is no leakage and, therefore, no contamination possible. The company have informed us that, due to an error on their part, the word *maximum* instead of **minimum** was used in reference to their patent straight-through diaphragm valves ("Plant Equipment News", *British Chemical Engineering*, 1956, **1**, 392, under Diaphragm Valves, line 9). This should have read: . . . the minimum resistance to the passage of fluids. Wynn (Valves) Ltd., Granville Street, Birmingham, 1.

BCE 604 for further information

R. & J. Dick have recently published their latest catalogue which describes the most recent addition to the Dick range of products, namely the Dixlink Vee Belting, R. & J. Dick Ltd., Greenhead Works, Glasgow, S.E., Scotland.

BCE 605 for further information

A new four-page catalogue by Jarrell-Ash Co. describes their Photo-processor for precisely controlled processing of research and analytical photographic emulsions. Information Service, Jarrell-Ash Co., 26 Farwell Street, Newtonville 60, Mass., U.S.A.

BCE 606 for further information

The 1956 Supplement to the 1955 edition of the Association's directory, "British Chemicals and their Manufacturers" has recently been announced. The directory is published at two-yearly intervals and all recipients who completed and returned the postcard included with the 1955 issue are on the mailing list and will shortly receive a copy. Copies are available free of charge from The Association of British Chemical Manufacturers, Cecil Chambers, 86 Strand, London, W.C.2.

BCE 607 for further information

A brochure giving details of the comprehensive engineering and consultancy service offered by Petrocarbon Developments Ltd., 17 Stratton Street, London, W.1, to the chemical and petroleum industries has recently been published.

BCE 608 for further information

We solved an 'insoluble' problem....

. . . and lowered the cost of producing caustic soda.

The shareholders of a firm of chemical manufacturers were making caustic comments on the cost of producing their soda. Until we were called in to give our advice. We turned to and churned out a completely new solution.

One of the main problems of caustic soda manufacture by the electrolytic method using diaphragm cells is the separation of salt from the caustic soda solution and the elimination of sodium sulphate. We knew that in a high gravitational field 'insoluble' sodium sulphate becomes soluble in brine. We knew that they found it expensive to purge their salt of sodium sulphate by existing methods. So we suggested centrifuging the salt with brine in the Sharples Super-D-Hydrator, using a special automatically controlled diversion valve to keep the mother liquor separate from the brine wash liquor.

This meant the rapid removal of sodium sulphate from the salt, using a comparatively small amount of brine. The result was a higher purity of sodium hydroxide, as well as the separation of a pure sodium chloride, extremely low in sodium sulphate and sodium hydroxide and a small volume of brine containing a high concentration of sodium sulphate. Less refrigeration was needed to precipitate this from the small amount of brine (reduced cost 1).

The time taken for the removal of the sodium sulphate was reduced from a matter of hours to about 10 to 15 seconds (reduced cost 2). Other advantages resulting from this made it possible to modernize the complete process of caustic soda production by the electrolytic method. *Savings of 15% in direct operating costs were the total result of calling for Sharples.*

This is a good example of the way the world-wide Sharples Centrifugal Engineering Service can help you solve a separation problem by the most efficient method. Sharples can offer you a complete range of centrifugal machines for any separation purpose.

Write to us and we'll be glad to send you a copy of our Bulletin No. 3054M—The Super-D-Hydrator. Or, if you wish, phone Amberley 2251/3 and talk to Martin Trowbridge about your problem.

The Super-D-Hydrator is only one of the wide range of Sharples Centrifuges at your service to solve your separation problems.

SHARPLES

ALWAYS TURN TO SHARPLES

SHARPLES CENTRIFUGES LIMITED, WOODCHESTER, STROUD, GLOS. *Telegrams: "Superspin," Stroud.*

World of Chemicals

New Compounds in U.S.A.

Monomethylol dimethyl hydantoin (MDMH) and dimethyl hydantoin formaldehyde (DMHF) resin are being produced commercially in the U.S.A. by the Glyco Products Co. Inc. The MDMH is in the form of white crystals, practically odourless, with a melting point above 110°C. It is soluble in water, methanol and acetone. It reacts as a substituted hydantoin and as an almost odourless formaldehyde donor. Heat alone produces liquid, soft or hard, water-soluble polymers. It reacts with proteins such as glue, gelatin, soy-bean protein and casein which it makes insoluble. DMHF, on the other hand, is a water-white resin having an initial softening point of approximately 60°C. It dissolves readily in water, giving solutions of low viscosity at high concentrations. It is soluble in alcohols, esters ketones, chloroform and methylene chloride and is compatible with gelatin, dextrin, starch, polyvinyl alcohol and neutralised polymethacrylic acid.

Salk Vaccine Exports

A fourth-quarter export quota of 7 million c.c. of Salk poliomyelitis vaccine has been announced by the U.S. Bureau of Foreign Commerce. A total of 1,474,522 c.c. of Salk vaccine was licensed for export in the third quarter. It was distributed among the following countries: Argentina, Belgian Congo, Brazil, Costa Rica, Cuba, Guatemala, Iceland, Israel, Norway, Panama, Paraguay, Uruguay and Venezuela.

Chinese Rubber and Coconut Oil Deal

China has concluded trade transactions estimated at about £5 million with Singapore and Malayan trade delegations. The chief items sold to China include more than 7000 tons of rubber and more than 2000 tons of coconut oil.

Esso Debenture Issue

The Esso Petroleum Co. has made a public issue of £10 million 5½% first debenture stock, 1974-78, at a price of 97%. The company is wholly owned by the Standard Oil Company (New Jersey) of the United States through its capital of £30 million in ordinary shares. The new debenture issue, the first to be made publicly by Esso in Britain, ranks with the existing £10 million of 5% first debenture stock, 1963-72, placed privately with institutions in February, 1953, at 99½%.

Antimony Find in the Himalayas

Antimony deposits have been found in the Himalayan ranges near the Bara Shigri glacier at an altitude of 14,800 ft.

Indian Applied Research

The National Research Laboratories of India are now drawing up their research programmes in conformity with five-year development plans. Each laboratory will be responsible for only a few projects of basic importance and will concentrate on them with a view to producing tangible results in a short period.

New Oil-distribution Centre

Shell-Mex & British Petroleum opened recently a new oil-distribution installation at Bridgwater, Somerset. It will be fed by estuarial tankers which will obtain most of their supplies from the Llandarcy refinery of B.P.

Expansion at Wilton

A further expenditure of £15 million on the Wilton Works, Yorkshire, has been authorised by the board of I.C.I., and the addition brings the total expenditure on the site to £90 million. The company is building there a second ethylene glycol plant, and is increasing its ethylene oxide production. The new plant will come into production early in 1959, at the same time as the third oil cracker from which it will draw its ethylene. The combined capacity of the two ethylene glycol plants will be 16,000 tons a year.

Chile Chemical Factory

A factory to manufacture auxiliary products for the textile industry is to be erected in Chile by the German firm Badische Anilin und Soda Fabrik A.G. Imports of machinery worth D.M. 43,000 (£3,900) and raw materials worth U.S. $90,000 (£32,000) have been authorised.

U.S. Polymer Factory

A plant costing $25 million to manufacture specialty acrylic polymers is to be built by B. F. Goodrich Chemical Co. at Calvert City, Kentucky.

Chemical Engineers Visit Moscow

Yugoslav chemical engineers recently visited Moscow to acquaint themselves with the plans for a nitrogen fertiliser plant now being designed there for Yugoslavia. The plant will be built on the site of natural gas deposits near Belgrade, and will have an annual capacity of 400,000 tons.

Marine Oil Survey in British Waters

In a search for oil-bearing rock formations, the British Petroleum Co. Ltd. carried out recently a geophysical survey to investigate the nature of the rocks beneath the sea-bed off Swanage and Ludworth Cove. It was the first waterborne survey to be organised by the company in Britain, and it was conducted from the converted corvette *Seislim*, the first British-owned vessel to be specially equipped for that work.

New Factories in Peru

A factory owned by Fabrica de Fertilizantes Industriales S.A., which will produce fertilisers from refuse from the city of Lima at the rate of some 150 tons per day, will shortly commence production.

Kahn & Co. S.A., of Iquitos, East Peru, are constructing a factory in Iquitos for the production of edible oils. Output will be 2½ tons daily of cotton-seed oil initially, and later it will include peanut oil.

At a factory being built in Lima by Detergents, Oils and Fats Industries S.A. (DORFISA), and scheduled to commence production soon, about 2000 tons of sperm oil and 6000 tons of castor oil will be produced annually. In addition, quantities of sulphuric acid and detergents will be made available for the textile industry.

Turkish Atomic Energy Commission

The Turkish Grand National Assembly has ratified the Law for the establishment of a national atomic energy commission, comprising representatives of interested Government departments and universities.

Air Conditioning by Electronics

An electronic air-conditioning system has been elaborated in the research laboratory of the Radio Corporation of America, Princeton, New Jersey, and it is expected to be commercially available within five years. The system employs wall panels in which are embedded 2-in. metal squares, each of which is attached to a small cylinder of thermo-electric materials. An electrical charge causes one end of the material to heat, the other end to cool.

Dutch Seamless Tubes

The annual report recently published, of the N.V. Rijnstaal, Holland (formerly J. W. Oonk & Co., of Arnhem), states that the company's new building for the manufacture of seamless steel tubes is nearing completion. Production of the tubes, a manufacture new to Holland, should begin within the next few months.

Nuclear Energy Developments in Dominican Republic

A nuclear energy plant for the Government of the Dominican Republic is to be installed at the mouth of the River Haina, near Ciudad Trujillo, by Glenn L. Martin Co., Baltimore, U.S.A. It will have a capacity of 12,000 kilowatts. In the search in the Republic for radioactive minerals which are believed to exist in the area of Los Gallegos, a zone where radioactivity is fourteen times greater than normal is reported to have been located.

Fertiliser Plant for Iran

A chemical fertiliser plant using natural gas is to be built by Union Chimique Belge for the Planning Organisation of the Persian Seven-year Economic Development Programme. Union Chimique are to send a mission to Iran to study the problem and decide on the site (which will be in the Khuzistan province) and on the productive capacity of the new factory.

BCE 540 for further information

Rust-Proofing with 'Rust-Anode'

Manufactured at Redhill, Dublin, Johannesburg, Brussels and Wiesbaden and used throughout the world

'RUST-ANODE' is in the nature of a paint and is normally applied to a steel surface by brushing; it leaves a coat of pure zinc which is strongly adherent, age-proof and rust-proof. Experiments have shown that the degree of protection afforded by such materials increases with the pure zinc contents of the coating. This protection is obtained in the highest degree by 'RUST-ANODE,' which gives as much as 95% of pure zinc in the dried film without sacrificing any essential characteristics. It is for this reason that 'RUST-ANODE' is referred to as 'cold galvanising,' since it gives an equivalent type of coating and when correctly applied has superior inhibitive qualities. One of the reasons for this superiority is that no intermediate film of brittle and rapidly corrodible iron-zinc alloy is formed as is inevitable with the hot-dip process.

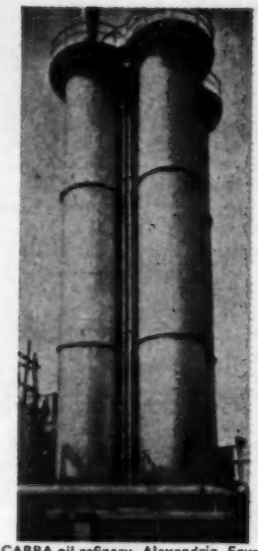
'CAPALLA' is a chemical pre-treatment for metals which destroys and neutralises existing rust, deposits an insoluble phosphate coat, and provides an ideal key for the adhesion of subsequent paint work. It is obtainable in all sizes for retail or industry. Start right and abolish rust troubles permanently.

'SKALINE' is a new and thoroughly reliable mill scale remover, the need for which has been felt in industry for many years. It is very simple to use, just brush it on the surface of the metal, leave for 15 minutes or more, if necessary, then hose off with water, when the surface will appear bright and free from scale. A most useful pretreatment before applying Rust-Anode where mill scale is prevalent and when sandblasting is impracticable or impossible on standing structures and equipment.

TEST WORK

This has been conducted by the Chemical Inspectorate of the Ministry of Supply and by an independent testing house indicated by the British Standards Institution.

Comparative tests were conducted simultaneously with 'Rust-Anode,' electro-zinc plating, hot spelter galvanising, and red lead coatings. They conformed to the B.S. 1391: 1952 performance tests for protective schemes; they included the A.R.E. salt spray test and the C.R.L. sulphur dioxide test. The results, which may be inspected in our offices, fully justify the claims made for the product.



CARBA oil refinery, Alexandria, Egypt coated with 'Rust-Anode'

A CAP PRODUCT

C. & P. DEVELOPMENT Co. (London) Ltd., Wiggie Works, Redhill, Surrey Tel. REDHILL 4554

and 88 GREENLEA ROAD, TERENURE, DUBLIN

"9-Group Protection"

solves Corrosion problems

In finding the right answer to many different plant-protection problems, St. Helens have developed nine comprehensive groups of natural rubber and synthetic compounds, including:

7: POLYCHLOROPRENE (NEOPRENE)
for conditions which involve elevated temperatures and/or oils, solvents and greases.

Other 'Cabtyrit' compounds include Natural Rubber, Heat-resisting and Abrasion-resisting Natural Rubbers, Ebonite (Hard or Flexible), Polyvinyl Chloride (P.V.C.) and Butyl.

St. Helens will be pleased to advise as to the most suitable compound for your particular purpose.

Please ask for literature or send details of requirements.

ST. HELENS

Technologists in Rubber and Synthetics

ST. HELENS CABLE & RUBBER CO. LTD., SLOUGH, BUCKS. Telephone : SLOUGH 20333

BCE 541 for further information

The Month's News in Brief

Chemstrand Ltd. announces that the contract for the design and construction of the £3¼ million Acrilan acrilic fibre plant near Coleraine, Northern Ireland, where preliminary engineering work and site development is now taking place, has been awarded to Costain-John Brown Ltd. It will take about two years to complete and the finished plant will produce 10 million lb. of Acrilan fibre a year in the first stage. Chemstrand also announces that it has opened its headquarters office, 8 Waterloo Place, London, S.W.1 (telephone TRAfalgar 1431).

British Titan Products Co. Ltd. is to extend still further its production facilities at Grimsby at a cost of more than £2 million. These extensions, which are due to be completed during 1958, will raise the production at Grimsby to 70,000 long tons a year, approximately seven times the output of the plant when it first started in 1949.

Hepburn Conveyor Co. Ltd. announces that it has obtained sole manufacturing rights in Great Britain of the Shot-blasting dust-control equipment of the Pangborn Corporation of Hagerstown, Maryland, U.S.A., and the selling rights for Great Britain, the sterling area, and non-exclusive rights for many other countries, including Germany and India. Hepburn hopes to be in production on the 6-ft Rotoblast table room model and the 6-cu.-ft Blastmaster before the end of this year.

W. J. Fraser & Co. Ltd. have been awarded a contract, worth approximately £750,000, for the complete installation of new nickel-refining plant at Clylach, South Wales, for the Mond Nickel Co. Ltd. The plant will carry out the final stage in the production of nickel, in which the pure metal is obtained by thermal decomposition of gaseous nickel carbonyl.

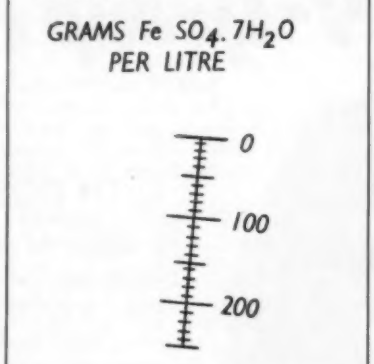
Keith Blackman Ltd. has acquired the majority shareholding of Blackman Export Co. Ltd. Upon the resignation of the existing board, the following directors were appointed: Mr. D. S. Woodley, chairman; Mr. A. L. Ayton, secretary; and Mr. A. H. Woodley. The company will continue its activities from its present address at 23 Queen Square, Southampton Row, London, W.C.1. Mr. G. L. Copping, who had served with the Blackman Export Co. Ltd. for the past 53 years, relinquished his directorship but will continue to serve in a consultative capacity.

The Tube Investments Atomic Energy Liaison Office announces that a contract has been placed with the T.I. company, **Accles & Pollock Ltd.**, to produce the fuel-element sheaths for the Dounreay experimental fast fission reactor. The order, which requires the production of niobium (or columbium, as it is more generally known) and vanadium tubes to extremely fine tolerances, is believed to be the first instance of these metals being fabricated in other than experimental quantities.

Metal Propellers Ltd., engineers of Purley Way, Croydon, who have specialised for many years in the design and fabrication of plant in stainless steel, have recently completed the erection of two new shops having a total area of nearly 20,000 sq. ft. This extension represents a further substantial stage in the planned development of Metal Propellers' factory site and, it is estimated, should permit an increased output of some 20%. Much of Metal Propellers' business is devoted to the design and manufacture of distillation equipment for oil refineries and chemical works, and the new 10-ton overhead travelling crane in the assembly bay, together with a 5-ton crane which runs the whole length of the two shops, provide greatly improved facilities for the manufacture of fractionating columns and other heavy items of stainless-steel plant. A 12-ft cube erection pit has also been provided for this purpose. The new shops form one long bay of approximately 350 ft, the first 150 ft of which is the new main assembly bay of 30 ft height to the eaves.

NOMOGRAM NO. 6

It is regretted that there was an omission in Nomogram No. 6 (*British Chemical Engineering*, 1956, **1**, 384). The numerals on the central scale were omitted and are as follows:



Alfa-Laval Co. Ltd. has opened extensive new process laboratories at its premises on the Great West Road, Brentford. This new building has been put up to meet an ever-increasing demand for experimental work in the application of De Laval equipment, including centrifugal separators, pumps, heat exchangers, filters, etc., in the chemical, engineering and process industries. The building includes process, engineering and chemical laboratories, photographic section, library and technical offices.

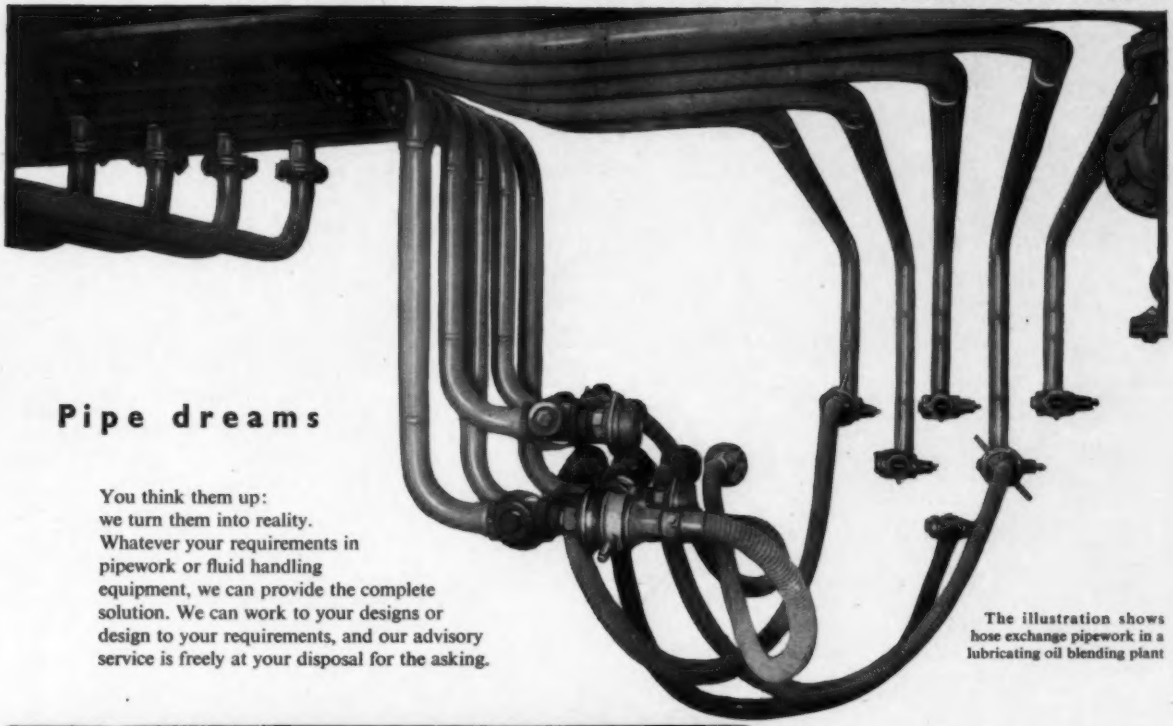
Remington Rand Ltd. opened what is claimed as the largest electronic computer service centre in Europe at the Battelle Institute in Frankfurt, Germany, on October 19. Dr. Carl Hammer has been appointed director.

Scene in the new assembly shop of Metal Propellers Ltd., Croydon, who specialise in the fabrication of plant in alloy steel. The large vessel shown in course of assembly is a Monel column for the absorption of ammonia from coke-oven gas and is 16 *ft in diameter and* 13 *tons weight.*

Birlec Ltd., a member of the A.E.I. Group, is about to build Britain's largest and most modern electric furnace manufacturing plant. Announcing a ten-year development plan, the company disclosed recently that a 34-acre site has been purchased at Aldridge, near Birmingham. First stage of the plan for the new factory allows for several bays, totalling approximately 150,000 sq. ft, to be completed in 1958. The immediate aim is to provide additional space for fabricating the massive parts of large industrial furnaces and other structures. Stages two and three of the scheme are planned for completion in 1961 and 1966 respectively. Provision will be made for large research and administration blocks, together with a new heat-treatment shop. Birlec's recently inaugurated apprentice-training scheme, which at present allows for an annual intake of about 50 apprentices, is integrated with this expansion project. The newly-trained recruits will, to a large extent, fulfil the additional requirements for personnel when the company moves into the new premises.

Below: Artist's impression of the new Birlec electric furnace factory. The first stage of the three-stage plan is scheduled to be completed in 1958.

BCE 542 for further information



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Sir Cyril Hinshelwood, F.R.S. (left), and **Professor Semenov** who are this year's Nobel Prize winners. See "Digest" this issue for further details.

A number of appointments at the Esso refinery and to the newly-formed refinery co-ordination group at the company's head office have been announced recently. **Mr. J. Bowen**, formerly employee relations superintendent at the refinery, becomes assistant refinery manager; **Mr. R. H. Angibault** succeeds Mr. Bowen as employee relations superintendent; **Dr. D. F. Jacques**, formerly cost superintendent, has been appointed process superintendent; **Mr. J. E. M. Jeffers** succeeds Dr. Jacques as cost superintendent.

Mr. John Ryan, vice-chairman of the Metal Box Co. Ltd., and **Mr. H. V. Stammers**, deputy chairman of the British Tabulating Machine Co. Ltd., have been elected vice-chairmen of the British Institute of Management.

R. Cruickshank Ltd., Birmingham, announce the appointment of **Mr. L. W. H. Eyers**, manager, London office, as staff director, London sales, and of **Mr. J. R. Burston**, formerly manager of the chemical division, as staff director, chemical division, West Bromwich.

Mr. E. H. Lewis has resigned from the board of the Tunnel Portland Cement Co. **Mr. S. V. Hagdrup** and **Mr. R. W. Bearne** have been appointed directors. Mr. Hagdrup is succeeded as secretary of the company by **Mr. H. Chapman**.

Mr. J. S. Roye has been appointed sales manager of the chemical and agricultural division of Pfizer Ltd. He succeeds **Mr. Ronald Page**, who has resigned to take over an appointment in the United States.

The Council for Scientific and Industrial Research has announced the name of **Dr. A. W. Lategan**, at present director of the National Nutrition Research Institute, as director designate of the South African Bureau of Standards. He will succeed **Mr. James Ritchie**, who recently tendered his resignation. **Dr. Lategan**, whose new appointment will be effective from November 1, has been a member of the Council of the S.A. Chemical Institute since 1947 and executive member of the Chemical Division of the S.A. Akademie vir Wetenskap en Kuns.

The National Coal Board announces that it has appointed **Mr. R. S. McLaren**, general manager of No. 3 (South-east) Area of their Durham Division, to be production director of that Division. Mr. McLaren succeeds **Mr. H. E. Collins**, who has been appointed director-general of reconstruction at National Headquarters.

People In The News

Mr. A. Knowles, manager of the Wembley works of British Oxygen Gases Ltd., has been appointed technical manager, acetylene, at the company's headquarters at Bridgewater House. He takes over the position formerly held by **Mr. E. A. Groom**, who is taking up an appointment with the parent organisation, the British Oxygen Co. Ltd.

Dr. J. E. Wallace Sterling, president of Stanford University and board chairman of Stanford Research Institute, has announced the appointment of **E. Finley Carter** as the director of S.R.I. Mr. Carter has also been named to the Institute's board of directors.

On her tour of Britain's first atomic power station on October 17, the Queen was accompanied by Mr. H. G. Davey, the chemical engineer who is the works general manager in charge of Calder Hall, Windscale Works and the duplicate of Calder Hall, now being built on Annan airfield, near Carlisle.

Many top-flight industrialists attended the official opening of Calder Hall, including Sir Alexander Fleck of I.C.I. (left), here seen talking with Prof. Neils Bohr (right), the eminent Danish physicist whose atomic theory was an essential prerequisite of modern advances in the atomic energy field. (Photo: Dr. A. M. Young).

The Council of the British Electrical Development Association announces with regret that **Mr. V. W. Dale**, Companion I.E.E., will relinquish his position as director and secretary of the Association as soon as his successor has been appointed and ready to take over. Mr. Dale, who is approaching the completion of 50 years in the electricity supply industry, is retiring on account of health considerations.

Mr. John Donald Moir Dunbar retired from the position of deputy manager of the production and technical department of Scottish Agricultural Industries Ltd. on September 28 after 50 years' service to agriculture. **Mr. W. L. Nicol** succeeds Mr. Dunbar as deputy manager.

The United Kingdom Heavy Engineering Misssion to India, formed under the joint auspices of the F.B.I. and the Colombo Plan, left England for New Delhi on October 23. Its object is to advise the Government of India on the further extension of heavy manufacturing capacity during the period of the Second Five-year Plan. An advance party of three experts **(Arbuthnott, Carter and Stitt)** spent a fortnight in India at the beginning of September, undertaking preliminary work of an exploratory nature. **Sir Eric Coates**, who led the Colombo Plan Steel Mission to India, will be chairman. Other members of the team are **F. E. Warner**, British Chemical Plant Manufacturers' Association; **J. W. L. Anderson; R. Arbuthnott; W. G. Carter; L. G. Earle; T. W. Hayes; W. C. Hunt; L. W. Needham**, joint managing director, Head Wrightson Colliery Engineering Ltd; and **D. J. Stitt**, director, Steel Works Plant Association.

H. Joseph Swezey, director of export sales of Du Pont's organic chemicals department, has retired after 37 years with the company. He is succeeded by **J. Preston Wills**, who has been assistant director of export sales since 1951.

Dr. F. J. Joubert, senior research officer of the Council for Scientific and Industrial Research, has been awarded a post-graduate bursary by the National Research Council of Canada and will spend approximately one year doing research in its Ottawa laboratories. Dr. Joubert is a member of the staff of the National Chemical Research Laboratory, where he has been responsible for research on proteins.

The Court of Glasgow University has appointed **Mr. D. L. Nicolson** to the Loudon lectureship in engineering production in the university.

Dr. Philip Howard Sykes is the chairman of British Oxygen Research & Development Ltd., the new company which takes over the work done by British Oxygen's Research and Development Centre at Morden. Dr. Sykes is a New Zealander and has been with British Oxygen since 1946.

Sir Peter Roberts, chairman of Newton Chambers & Co. Ltd., was installed Master Cutler on October 2. He is also chairman of Wellman Smith Owen Engineering Corporation Ltd. The ancient Cutlers' Company, of which he is now Master, in its modern activities represents the industry and business section of Sheffield life and is influential in steelmaking spheres as well as in the cutlery trade, with which it was originally solely associated.

Dr. P. H. Sykes *Sir Peter Roberts*